RURAL TEXT-BOOK SERIES

BEGINNINGS IN AGRICULTURE

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BEGINNINGS IN AGRICULTURE

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BEGINNINGS

IN

AGRICULTURE

BY

ALBERT R. MANN

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PREFACE

This book is designed for the purpose of introducing the study of agriculture into the seventh and eighth grades of our elementary schools. It may also meet a need in some of the smaller high-schools and in ungraded special and private schools. When the pupil comes to well-developed high-school work, he will need a more detailed and specific text.

The book is founded on the suggestions in the Report of the Committee on Industrial Education in Schools for Rural Communities, of the National Educational Association. That Committee recommended for the school years 6 to 8, four sets of subjects as follows: first half year, the affairs of agriculture; second half year, the soil; second year, farming schemes and crops; third year, animals. A condensation of this plan into a two-year scheme has been attempted in the present volume.

It has been the aim of the author to cover the work very largely in a nature-study spirit, by which it is meant that the pupil shall be brought into as close touch as possible with the actual farms, soils, crops, animals, and affairs. The problems are intended to set the pupils at work on their own account rather than to enable them to answer questions that may be suggested in the text.

It is, of course, essential to practical school conditions that there shall be reading-matter and recitation-matter in the book. Perhaps Part I, dealing with the general agricultural situation, may be used as a series of introductory reading and discussion exercises, the actual work with subject-matter to begin with Part II. The open-book method of teaching, now used successfully in many schools for history and geography, might be employed advantageously with this text, especially in schools in which nature-study receives little attention.

It is assumed that the teacher will see that the pupils work out the problems, or as many of them as have useful application to the affairs of the particular community. It is to be hoped that there will be a school-garden on the premises, or that small areas may be set aside at the homes of the pupils, on which many of the suggestions in the book may be worked out personally. It is specially to be desired that the parents be brought into the work, in order that the agricultural affairs of the community may be related to the school. Therefore, a large number of problems have been presented with this end in view, the expectation being that the pupil will ask the parents for the proper solution of the questions.

Field trips, to study at first hand the subjects discussed in the lessons, will add greatly to the interest and value of the work, and will give it local and personal application. It is important that the pupils shall study the things themselves, so far as it is possible, rather than study about them.

The author realizes that it is very difficult to introduce agriculture on a uniform basis in the schools in all parts of the country, owing to the marked diversity in agricultural conditions; yet there are certain common and underlying problems and situations with which all school children should be familiar. The aim of the book has been to relate the pupil and the school to these general and essential situations. It is assumed that detailed technical discussions of the modes of raising certain crops and animals should not be introduced into the elementary grades. This part of the work must be reserved for the high-school and the college.

A. R. MANN.

Ithaca, New York,
June 1, 1911.

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PART I

THE AFFAIRS OF AGRICULTURE

CHAPTER I

THE COMMUNITY IN WHICH I LIVE

Happy the man whose wish and care
A few paternal acres bound,
Content to breathe his native air
In his own ground. — POPE.

IT is a beautiful country in which I live. To the south is the village, with its churches and school, and with little dwelling-houses scattering out into the fields. There is a factory with tall chimneys that roll out windrows of smoke. On all other sides is the wide open country. There are long meadows, and hills that slope up to the sky. There are winding roads, bounding broad, green, fertile fields. There are brooks that dash down the hillsides and then wander over lowlands and sleep in the deep marshes. There are dense pieces of woodland and sentinel trees standing in the fields. Beyond the nearest highway is a sandy field in which sorrel grows. To the west of the road is land of hard clay, now rank with grass and clover, and in the spring yellow with the gold of dandelions. Beyond the barn is a wild sweep of pigweeds, invading the land that has been neglected and teaching lessons of thrift and of ability to seize opportunities. There are cattle dozing under maple trees at noonday. There are flocks of crows that travel westward in the morning and eastward at night. Stretching outward one sees miles of corn and meadow and grain and other crops.

The work that we do. — Every family in this country where I live has its own means of gaining a livelihood. One man is a stone mason. Others work in the factory. Several buy and sell in the village. One is employed by the government to care for the mails.

Some are physicians, some clergymen. Many are farmers. All together they make up the community, each person contributing some share to the welfare of the whole. Every occupation in which they engage is necessary, and therefore one is as worthy as

Fig. 1. — There are grain fields, and hills, that slope up to the sky.

another. My father's occupation is farming, and he is a member of the community.

The division of labor. — One part of the community depends on all other parts. If the blacksmiths should move from the village, father would be obliged to drive six miles farther to have his horses shod, and that would mean less work done on the farm or else

extra labor to hire. If those persons who produce milk were to retire from the business, the village people would be obliged to keep cows, or to pay to have milk brought in from other places. There is division of labor, — one person performing one kind of work for the community, another person performing some other work. Each depends on the other, and the welfare of the community is dependent on all.

Problem 1. How many kinds of occupations are represented in your community, — say in your school district? What do the people do for a livelihood?

Problem 2. What is the leading occupation, — the one that engages the greater number of persons? Would you say that your community is a farming community, manufacturing community, trading community, wage-earning community, or some other kind?

Problem 3. Tell what is the leading farming occupation. Do most of the farmers call themselves fruit-growers, or dairymen, or grain-farmers, or general farmers, or stockmen, or gardeners, or florists?

Problem 4. Are there any establishments in the community, or nearby, that make manufactured products from the materials that the farmer raises, — as beet-sugar factories, cotton mills, creameries, canning factories, grist mills, cider mills, pickle factories?

Problem 5. Are there any establishments that manufacture articles chiefly for the farmer's use, — as barrel factories, fertilizer factories, implement factories? Perhaps your teacher will want you to visit one or more of these establishments, and then to describe them.

CHAPTER II

THE GEOGRAPHY OF THE LOCALITY AND THE CONTINENT

A GREAT many years ago, when our country was new, pioneers came and settled in this protected valley. Their families grew up, other families moved in, the store and the shop came, and there was established a community. One after another, settlements sprang up in other localities, farther to the west, in like manner.

The local geographical conditions. — In each of the communities the leading industries were determined largely by the special natural advantages which the locality offered. One, because of good water power, became a manufacturing center; another, by the river, became a shipping or commercial center; one, in a cold and densely wooded region, became a hunting and trapping center; others, with rich soil and favorable climate, became farming centers. Some of the farming regions had long seasons, some short; some had much rain, others little; some were on steep, rocky hillsides, others in rich, deep valleys; some developed one kind of farming, some another kind.

This region is part of the world. — There are many conditions in this local world, in which the school-house and the farm-house are the centers. If the locality were to be magnified one hundred or one thousand times, we should have such conditions as make up a state or perhaps a whole country. We should then have greater range of climate, more varieties of soil, more kinds of animals and of plants. Now that we know something of our local world, we may learn of the greater world beyond.

The continental topography. — Geographers tell us that the United States, not including its possessions, covers an area of

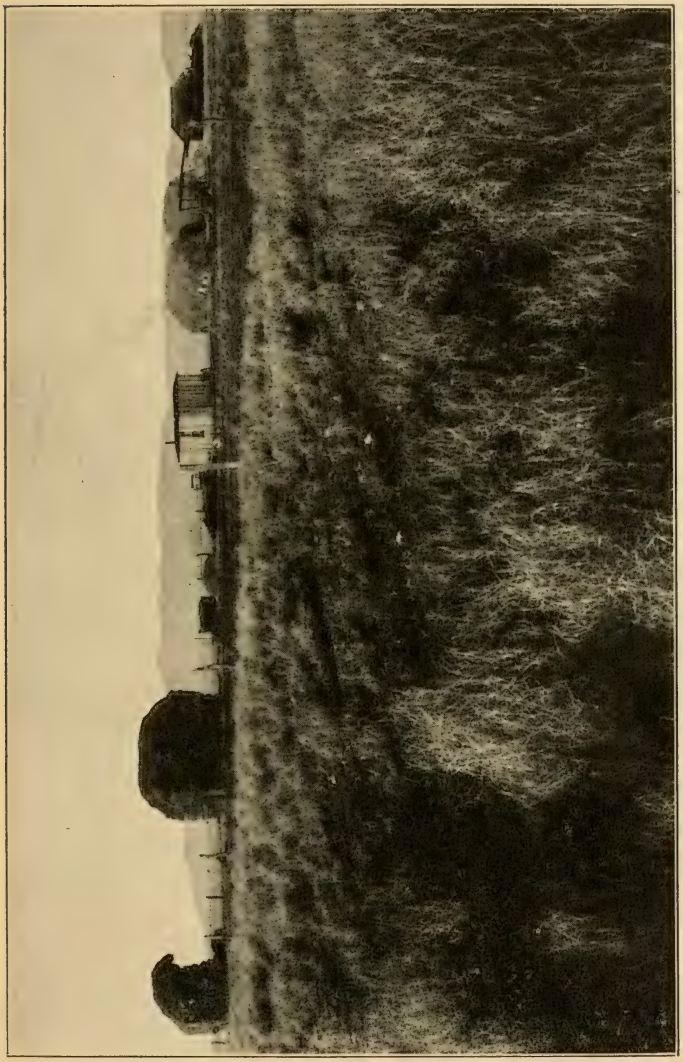

FIG. 2. — A homestead in a region of scant rainfall, Arizona.

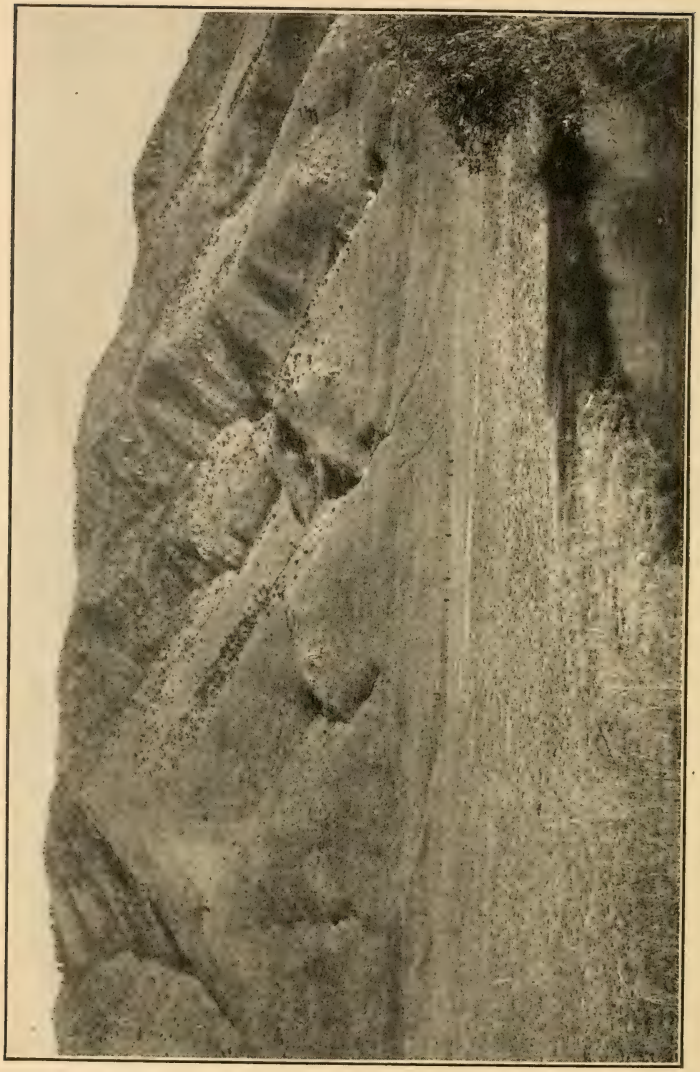

FIG. 3. — The Topography varies, and also the plants that are grown.

3,026,789 square miles. Canada is even larger, with 3,745,574 square miles. This vast area, extending from the ever-frozen and desolate north to the warm sub-tropical south, is broken by lofty mountains ranges, between which nestle fertile valleys and broad plateaus, winding rivers, and broad, deep lakes that help to keep the balance between the cold of winter and the heat of summer. These varying physical features unite to form what we call the topography of the land.

Plant geography. — Because of its great extent and varying topography, and the conditions under which it was formed, North America has many different kinds of climate and of soil, and therefore has a great variety of plant life. In the far north, where the ground is always frozen, except a thin surface layer for a few weeks in summer, vegetation is very scant; there are a few scrubby willows and birches, and short-season grasses and flowering plants.

As we move gradually southward we find a greater range of plant life, and the plants grow more profusely. Along the southern border of the great forests of Canada and jutting down into the United States, there is a region where wild small-fruits abound, as blackberries, raspberries, and cranberries. Here, in places, the potato, timothy-grass, and some of the more hardy grains thrive.

Moving southward again, we enter the warmer, humid regions, those having moderate rainfall, and including southern Canada and most of the United States, except large areas in the southwest. In this region we find such crops as wheat, oats, rye, barley, varieties of corn, potatoes, sugar-beets, and tree-fruits in the more northern parts, with the addition of peaches, flax, hemp, lima beans, sorghum, and tobacco farther south. In the extreme south, cotton, sugar-cane, rice, peanuts, pecans, oranges, and lemons are staple crops.

In the arid and semi-arid regions in the southwest, where the rainfall is insufficient and irrigation is required to grow crops to advantage, corn, grains, potatoes, sugar-beets, fruits, alfalfa, kafir corn, sorghum, sweet potato, and tobacco are grown.

There is a constantly changing farming, with different kinds of crops, as we move from one geographical region to another.

Relation to markets. — After the plants and animals are grown, the farmer must place them on the best markets; he needs good avenues of transportation to reach the markets. Here, again, the geography is important, — the nearness to cities or shipping ports, and the accessibility of rail and water routes. The farmers in a locality will produce the kinds of crops and animals for which they have a market, and which they may transport to market by the means that are available.

The geography of a locality, then, has much influence in determining the kind of farming, as the plants must be chosen to suit the soils, the climate, and the markets.

Problem 6. What are the leading crops in your state or general geographical region? Are some crops grown more largely in certain parts of the state than in others? Can you tell why?

Problem 7. Is the rainfall in your locality sufficient to meet the needs of the farm crops? Is the growing season long or short? If there are high hills, is the season any shorter on the hilltops than in the valleys?

Problem 8. Are there different kinds of soil in your locality? Are some much wetter than others? Do some contain much more sand than others? What kinds of plants grow on each? Is there any noticeable difference between the soil on the hilltop and that in the lowlands?

Problem 9. Determine what kinds of farm produce are sold by the farmers, and whether the products are sold in your village or city, or shipped away. If shipped away, where do the products go? How many kinds of shipping facilities are there, and what kinds of products are shipped by each?

Problem 10. With a map, trace out the leading farming regions on the continent.

CHAPTER III

AGRICULTURE

One of the occupations in which persons engage is agriculture; and more persons are engaged in this occupation than in any other. About one-third of the population of North America are farmers Farming is therefore the most important industry in this country. It leads also because it produces most of the food-supply for the nation, and the raw materials for many other industries.

What agriculture is. — When we use the word "farming," we think of the running of a farm and the raising of products on the land. The products are plants or parts of plants, which we call crops, and animals or their products. When we speak of "agriculture," we mean all the enterprises connected with the farm in addition to the raising of plants and animals. Agriculture is a broader term than farming, and includes marketing, the making of farm buildings, good roads, farm forests, farm machinery, farm labor, the farm home, farm life, and everything else in which the farmer is interested in connection with his business.

Agriculture was the first settled occupation of man. We read that the first man whom God created was placed in a garden to keep it. From that time to the present, all progress of the human race has been closely associated with agriculture and dependent on it.

Indian agriculture. — Before the white man came to America, the Indians cultivated a few plants for food, more especially maize (commonly known as Indian corn), and beans, squashes, pumpkins, and sunflowers. Cotton and tobacco also were cultivated. Most of the food-plants of the Indians were harvested in their wild state,

without cultivation. When Jamestown was founded, every family of the Algonquin, or Virginian Indians, had its garden, prepared by the men and planted by the women. The New England Indian families also had their gardens of one half acre to about one and one half acres in extent, which they tilled with their clam-shell hoes. The families helped one another, and when a field was to be broken up, as an old chronicle records, they had a "loving, sociable, speedy way to dispatch it. All the neighbors men and women, fortie, fiftie, etc., joine and came in to helpe freely."

The southeastern Indian towns had their farms in one piece, in which each family had a small lot fenced about by a strip of grass, poles, or other means. Each year they elected an overseer who directed all the garden work. At daybreak he awakened the families by a loud cry, gathered the men with their simple tools in the public square, and at sunrise led them into the fields. Later the women came with the provisions.

The southwestern Indians, in the arid regions, conducted farming by means of irrigation.

While the Indian methods of farming were crude, yet the early colonists found a system of agriculture that was of great help to them.

Colonial agriculture. — The colonists continued the cultivation of corn, tobacco, cotton, beans, melons, squashes, and potatoes, which they found here, and they introduced many crops from Europe. Wheat was the first crop brought over by the Virginia colony. At this time the chief live-stock was hogs and goats, and a few cows; but cattle were rapidly introduced from Europe. The first cattle ranches in America were in Virginia. From the first the colonists had a few horses for use as pack animals, but most of the farm work was performed by oxen.

Cattle were brought into New England in 1624, but cattle-raising did not become important at that time, except for dairying. Corn was the most important crop. The New England colonists followed the Indian custom of planting beans and pumpkins

among the corn. Wheat, rye, buckwheat, and barley were grown to a limited extent. The native grasses were cultivated, among them timothy, which has remained the principal hay crop to the present day.

The westward growth. — With the close of the Revolutionary War there came to the colonists in the United States a vast territory reaching westward to the Mississippi River, and agriculture was extended to the west and south. Cotton became the most

Fig. 4. — With the westward growth, cattle ranches were established.

important crop in the south. Mules were raised for work on the cotton plantations. Live-stock raising took on new importance, and cattle, of both milk and beef breeds, and horses were imported, especially from England, in large numbers. Much attention was later given to the improvement of farm machinery, and new and better implements were introduced. Farming became more specialized as better means of transportation were provided. More than 30,000 miles of railroads were built before 1860. The improvement of plants and animals went hand in hand with the importation of the best animals from Europe.

As still other land to the west was added to the area of the United States, agriculture gradually pushed to the Pacific coast, and the

large cattle ranches of the middle west, and the great wheat and corn farms, were developed. Railroads were extended, and many new labor-saving farm machines were devised. The grain separator or thresher, the twine-binder, the check-rower, the weeder, the riding cultivator, the disk harrow, the Babcock test, the cream separator, among many others, greatly affected the methods of

Fig. 5. — Extensive wheat farms were developed.

arming. As the arid and semi-arid regions were invaded, farming by irrigation was developed.

In Canada, the westward expansion came more slowly, although a very effective agriculture developed in the older eastern provinces. With the recent completion of great continental railroads, however, the vast western Canadian country was opened up, and the great provinces of Manitoba, Saskatchewan, Alberta, and British Columbia are already large producers of wheat, cattle, and other products. The greatest expansion into new territory on the North American continent is now taking place in these provinces.

In the last thirty years, farming in the United States and Canada

has made noteworthy advancement. Agricultural colleges, experiment stations, and departments of agriculture have been estab-

FIG. 6. — When the arid regions were invaded, farming by irrigation became necessary.

lished, and much expert attention has been given to the problems of the farmer.

Values. — When we compare agriculture with other industries, we find it far in the lead in its investment and output. A single farm may not seem to be a large business, but when we add together

the money invested in all farm property in the United Staes, the sum is more than twice as much as the capital invested in all manufactures. There is one half more horse-power used on American farms than in all our factories. The agricultural exports are more than half as much again as all other exports.

Problem 11. What proportion of the people in your locality are farmers? What proportion are engaged in manufacturing? What proportion are merchants? Which group, as a whole, has the most money invested in its business?

Problem 12. What farm products are shipped from your vicinity? What manufactured products? If we could put all the farm products together, would they have greater or less value than the manufactured products? The manufacturer makes his living by what he sells. Does the farmer make a considerable part of his living aside from what he sells? The manufacturer may seem to handle more money than the farmer. Which has to spend more?

Problem 13. Can you find out who was the first farmer in your locality and what kind of farm he had? Which are the oldest houses? Do they stand near the main road? If there are fences, which are the oldest and how are they built? Did the farmers in your locality always conduct the same kind of farming as now? Are there any evidences left by Indians to show that they once lived there?

Problem 14. Relate any history or historical incident that illustrates the agricultural development of your locality. Write an account of any of the leading former farmers of the locality.

CHAPTER IV

THE FARMER

We have learned that farming is the greatest industry in the United States and Canada. It is worth our while to become acquainted with the man who, on his own farm, master of his work, makes it so.

What the farmer contributes. — There are three things we all must have in order to live, — food, clothing, and shelter. We may

Fig. 7. — The farmer is master of his work.

let all other possessions go, but these three are indispensable. Where can we get them except from the farm? All our food (except that from the sea) comes originally from the farm, or at least from the land; silks and woolens, cotton goods and linen goods, all are made from animal and plant products raised on the farm; the wood for buildings is taken from the great farm, for trees are a farm crop, as we shall learn later. These necessities are what the farmer contributes to the nation.

Nature of the farmer's business. — Every man in the community has his business, his means of earning a living and of helping others

to live. The farmer's business is to make an honest living from his farm, by the raising and selling of crops and live-stock, or their products. His business is very different from that of other men. He buys relatively little and usually does not sell the things that he buys. He produces the things that he sells, and brings to the market newly created materials. Even when he buys materials to sell, he multiplies them or increases their value. When he buys cattle to sell, he usually keeps the cattle until they are mature or

FIG. 8. — Stock is reared for sale.

fat; he makes his money largely on the feeding and the care that he gives them.

In some parts of the country, most of the farmers make their livelihood from selling butter and cheese; in others, from selling milk; in others, from selling corn; in others, from selling cattle and pigs to which the corn has been fed; in others, from cotton; in others, from vegetables or fruit or grain; in others, from flowers and nursery products. As in the village there are general stores, in which one can buy almost anything he needs, and special stores, in which he can buy drugs or shoes or clothing or jewelry, so there are general farms and special farms. One farmer may produce milk, eggs, fruit, grain, and potatoes for sale; another may produce

only vegetables or cotton or wheat or fat stock for sale. The character of one's business, or farming, is determined by the kind of product that he sells.

The farmer must make an honest living, — he must not rob his land. His success depends on the fertility of his land. As the manufacturer invests money to keep his buildings and machinery in repair, so the farmer must keep his factory, or his land, at its best, so that he can have a permanent paying business. Time and money invested in keeping the farm in repair usually pay large dividends. The best farmers are the ones who apply business methods in their farming.

The farmer's year's work. — Nearly every day brings to the farmer a new task, calling for a different kind of effort and drawing on new powers within him. A progressive farmer must be a growing, broadening man, becoming more intelligent and more expert with the years. While he works with his hands, his mind will be active in solving new problems.

Every farm boy and girl knows that the farmer has his full year's work. In the winter, when the land is quiet, and while he is feeding his stock and perhaps getting out his wood, he becomes carpenter and mechanic as well as farmer, and repairs his buildings and tools and machines and makes the many things that he has needed, but has had to wait for. At the same time he is looking forward to spring and summer so that he may not be unprepared for them. If he is a careful man and takes stock of his business, now is the time when he will cast up his accounts and discover the real gains and losses, and determine changes in his farming.

When the frost is out of the ground, and the warm days begin to come, the father and his son swing into the furrow behind good, steady teams and turn over great stretches of land for the summer's crops. Then follows the fitting, the seeding, the care, on to the harvest — the hay and the grain harvest, the corn harvest, and the apple harvest. And each morning and evening, as the sun rises, and before it sets, the cattle may be driven to the barn,

milked, and returned again to pasture. If he is a grain farmer alone (as in same parts of the west and of California), he may take a vacation after the harvest.

As the fall draws on, and the crops are securely stored for the winter or sent to the market, the slaughtering is past and the smoke-house closed, and perhaps a few acres have been plowed so as to be beforehand in the spring, the farmer has the sense of satis-

Fig. 9. — The farmer swings into the furrow behind a good, steady team.

faction in the work of his hands. But he is not through. To-morrow will have its tasks. He is ready for them.

Problem 15. What does your farm contribute to the community? What kinds of food products do you sell?

Problem 16. Go to the grocery store and look over the stock on the shelves. How much of the grocer's stock came originally from the farm? How much of it might have been produced in your locality? What would become of the grocery if the farms should cease to produce? What would the people in the villages do if the grocery store had to close? Are the people dependent on the farmer?

Problem 17. If any of the farmers in your locality keep sheep, what is done with the wool? What farm crops enter into the making of cotton goods and linen goods?

Problem 18. How many buildings in the locality can you name that were built from lumber taken from the woods in the vicinity? Is there

any kind of factory in the vicinity which uses the wood from the farms?

Problem 19. Does your father keep an account of his farm transactions? How much did he get for his wheat last year? For his hay? From his cattle? Do you know how much it cost him to produce any of these?

CHAPTER V

THE FARM

The farm is the farmer's place of business. It is the means by which he earns his living and contributes his part to the community. There is buying and selling. There is production and distribution. The farm is a commercial establishment.

The farm establishment. — In our grandfathers' time, not only were food and materials for clothing produced on the farm, but here, also, the finished products were manufactured. Those were the days of homespun. Now the manufacturing is largely a distinct business, and the farm merely provides the raw materials.

Yet we may say that the farm is the greatest of all factories, for it yields new materials that can never be created by machines made by man. The farmer plants his seed, gives it care, and the great soil-and-air factory slowly but surely turns out its wonderful product. And it yields its products, not one at a time, but in numbers too great to be counted.

There are three elements or parts to every farm that must be considered in making a plan for the business, — the home, the farm buildings, and the land.

The home. — Farming is practically the only business of which the home is a part. In nearly all other occupations, the man leaves the home and goes to his work or his business in the morning, and returns home at night, leaving behind the affairs of the day. The farmer lives with his business. The home is, therefore, an essential part of his business, and must be so ordered as to help him; and he must take it into consideration in all his plans for his work.

The farm buildings. — We are likely to judge a farm by its buildings, for they generally reveal thrift or carelessness on the part of the owner. And they are a fair test, for they indicate the farmer's care for his crops and his animals, although the farm may not be profitable in proportion as the buildings are attractive. Good buildings are a help to the farmer, not only for the comfort they bring to his live-stock and the protection of his harvested crops, but as well because they teach order and care and pride.

FIG. 10. — We are likely to judge a farm by its buildings.

The house and the farm buildings are part of the farm investment, and they must yield returns to the farmer in good and long-continued service.

The land. — The land is the most important part of the farmer's investment, as it is to give him his living and yield his largest returns. It is his most valuable trust, and must be carefully safeguarded, not only for his use, but for the use of all who will come after him. The value of a farm to the community depends on the land and the use that is made of it. The land largely determines the kind of farming that is to be done, the products that are to be sold, and the work the farmer has to do.

The plan of the farm. — Any business, if it is to be successful, must be well organized. This is especially true of the farm because

of the distances that must be traveled in doing the work. The farmer should organize or lay out his farm so that he will have to travel least in doing his work, as travel takes time and time costs money, and it consumes his energy. He must be able to reach all his fields in the most direct way, to avoid long hauls. He places the garden nearest the house because it is most often visited.

Fig. 11. — Negro farming in the South.

The barns and pens are generally near the house also, as the farmer must go to them very often to care for his stock. They should be placed where they can be reached most conveniently.

Some parts of the farm are better adapted to the kinds of crops the farmer wishes to grow than are others; the soils, elevations, exposures, and other natural features are different and must be taken into account. The size and shape of the fields must be considered in connection with the rotation of crops that is to be fol-

lowed. The size of the fields will also affect the ease with which the work may be done and the kind of machinery that may be used. The farmer may have to contend with creeks, woods, hills, or other natural boundaries in laying out the fields on his farm.

It is just such factors that make a farm plan necessary. The farmer must include every part of his farm in his plan, so that it may all be used, year after year, for the largest return at the least expense, without lessening the fertility of the soil. The way in which he subdivides his farm, therefore, determines in large measure the success of a man's farming.

Attractiveness of the farm. — Our lives are greatly affected by the conditions in which we live. No one cares to live in a run-down, unattractive place. One slovenly farm is a blot on the neighborhood. As the farm is the farmer's permanent home, it should provide as much beauty and attractiveness and homelikeness as possible. The farmer has the means to make his home surroundings delightful. Simple planting, in good taste, and a neat and picked-up appearance are the first steps. An attractive farm contributes more than merely its products to the community; its own influence for order and neatness is worth while. Better men and women grow up in neat, attractive, healthful surroundings.

Health of the farm. — The farm should provide the most healthful surroundings, since it can supply room, sunlight, fresh air, unadulterated food, and exercise. But the farmer is in danger of taking all this for granted and becoming careless. Neglect is sure to bring disaster. There are many ways in which disease may enter; one is through the water-supplies, and the farmer must be on his guard against such dangers about his home. Every farm should have a complete water-system, with provision to carry off the waste. Proper sanitation is as necessary on the farm as in the city, and it is not impossible to secure. It is wiser to provide for health than to fight disease.

Problem 20. How large, in acres, is the farm on which you live, — your father's place of business? What is the shape of it: oblong, square,

irregular? In what direction does the long way of it extend? How is it subdivided? An outline sketch or map, made by simple lines, will help you to understand the farm. Perhaps your father has a plan of the farm; if not, you can help him to make one. Has the farm a name? If you do not live on a farm, secure similar information from some person who does live on one; or, better, if possible, visit the farm and find out for yourself.

Problem 21. Is the farm uniform (practically all alike) throughout? Explain whether it is level, hilly, or swampy in parts. Tell whether there are brooks, ponds, rocks, or other natural features.

Problem 22. Explain what is chiefly produced on the farm. Also, whether any of the farm is in woodland; whether any of it is in waste or not in use; about how much is "under the plow"?

Problem 23. Is there much sickness on your farm? What is the cause? Is the well below the barnyard so that there may be drainage into it? How could you get a water-system into the house?

Problem 24. Give what history you can of the farm: when it was first made into a farm; from whom the first farmer procured it; who has owned it from first to last; whether any unusual events or persons are associated with it.

CHAPTER VI

THE FARM PLANTS

Plants and animals are the products of agriculture. Plants are raised either for food, clothing, or shelter, or for the farm animals, or to supply materials used in the arts, or for pleasure. The plants make it possible for the animals to live, and both are necessary for our food-supply.

Plants are grown for food. — A variety of plants must be grown for food, some kinds to be cooked and others to be eaten just as they come from the field or garden. The housewife goes to the garden to get potatoes and turnips and tender sweet-corn and green peas to cook, and onions, radishes, and lettuce to eat fresh and crisp. The farmer must supply equally nutritious foods for his live-stock. They require good, attractive food in variety if they are to do the work for which they are kept. Cattle like clean timothy, clover, or alfalfa hay, and hearty foods, as corn and cottonseed meal and gluten meal, and juicy or succulent foods, as corn silage, sugar-beets, or mangels. Generally, the larger part of the crops grown on any farm are to be used for human or animal food.

For manufacture. — Many products are of little use in the form in which they are harvested, and must be sent to various factories, where they are changed and made into other materials. Cotton is made into cloth, and flax into linens or binding twine; hemp is manufactured into burlap, twine, and carpet warp. From sugar-cane and sugar-beets sugar and molasses are made. From potatoes starch is manufactured. Some plants are grown for medicine, some for oils or extracts, some for spices, some for perfumery, some for dyes.

For building. — Other plants are grown for building purposes. They are harvested in the woodlot or forest. They are of many kinds: some are hard, others soft; some of one color, some of another; some grow large, so as to make long, clean lumber, and others grow small and knotty. Because of these differences, these plants serve a great variety of purposes in building.

For pleasure. — Another group of plants is raised solely for pleasure, — because they are beautiful and fragrant, and make the place attractive. They are usually flowering plants, but not always. They are grown close by the house, or at the side or corners of the lawn, or apart in carefully kept beds. They may be grown in glass houses or in fields as crops to be sold. The florist is a farmer, because he raises plants.

Relation of plants to soil fertility. — If the farmer is to secure the best results from his land, and keep it fertile, he must grow a variety of plants. If one crop is grown continuously on the same land, the fertility of the soil will be lessened. Many cotton plantations in the south and wheat and corn farms in the west yield much less now than formerly because one crop has been grown continuously. When several kinds of crops are grown in succession, or rotation, the demands on the soil are varied; and in the rotation some crops may be grown to turn under and enrich the soil.

Special kinds of plants, called legumes, as clovers, vetches, and alfalfa, will enrich the soil greatly when plowed under. As plants helped to form the soil in the first place, they are valuable in renewing it when turned back into it.

Relation of plants to climate. — There is still another reason why different kinds of crops are grown in different localities. The plants must be suited to the climate. Some crops demand a long growing season, while others prefer a short season; some require a hot, dry climate, others a cool, moist climate; some need much rainfall, others little. The plants that we grow must be suited to the climate of our region. A few miles to the north or south the

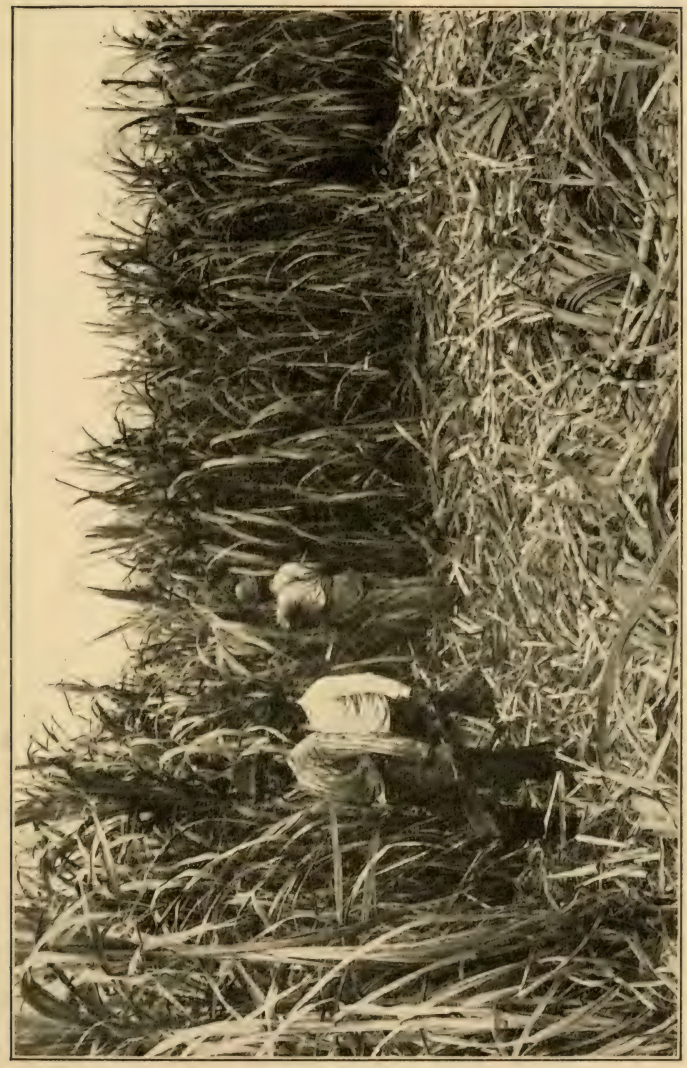

FIG. 12. — Sugar-cane is grown for manufacture.

FIG. 13. — Plants may be raised solely for pleasure. (p. 30)

same plants might not do well at all. The northern farmer does not attempt to grow cotton or sugar-cane or peanuts or oranges. The southern farmer does not plant buckwheat and but little rye or oats, or root-crops for live-stock. There are different varieties of wheat and corn for the north and the south. Each region has its own varieties of crops.

Relation to farm work. — The kinds of plants that the farmer grows bear a close relation to his work. If he raises garden vegetables or flower plants, which demand constant careful attention, we say that his farming is intensive. If he grows great areas of wheat or corn or sugar-cane, we say his farming is extensive. With such large areas he cannot give much care to individual plants, except in fitting the soil, planting, and harvesting.

The hay-farmer has his busiest season in mid-summer; the orchardman in late winter and spring with his pruning and spraying, and in the fall with his harvesting and marketing. The work of the stock-farmer is different from that of the crop-farmer, as he markets a different kind of products; that of the rice-farmer and poultry-farmer is different from any of the others.

The vegetable-gardener, using his land intensively year after year, must apply a great deal of fertilizer. The extensive farmer cannot afford to invest much in fertilizer, and must renew his land by crop rotation and the plowing in of vegetable matter or cover-crops.

Plant societies. — Plants have associates and grow in societies. They must live together and get along together, just as folks must do; and to do so, some must yield the best places to others. Plants become accustomed to each other. Some can live in the shade, as in the orchard or in the forest; and since they cannot rise into the sunshine and wind and storm, they are content with the cool, moist, quiet protection that is given them by their superiors. The pumpkin vines yield the sunlight to the tall corn, which is a sun-loving plant, and in its shade live their lives mostly unnoticed until harvest.

Different kinds of soils and locations are associated with different plant societies. In the hard-tramped door-yard there is a society of knot-weed and broad-leaved plantain, with occasional blades of grass and dandelions; in the fence row there is a society of briars and choke-cherries and hiding weeds; in the dry, open field, the wire-grass and mullein and scattered docks associate; in the old pasture the blue-grass and mullein and daisies and devil's paint brush live together; in the meadow there is timothy, the lower-growing clover, young grasses, and other plants among the grasses.

Fig. 14. — Plants have associates. Corn and cowpeas.

Some plants associate only with certain others. Cockle associates with wheat, not with oats or corn. Peas and oats will abound in the same field; timothy and clover, corn and pumpkins, barley and peas, cowpeas and sorghum or millet, are close companions and will share a field together. This association may be due wholly to adaptation to each other, or to the fact that one (as the cockle in the wheat) has such a life-history and size of seed as will allow it to pass unnoticed with the other.

The farmer takes advantage of plant societies and companions in planning his cropping systems.

Problem 25. Why is one kind of farming in your locality different from another? What kinds of crops does the dairy-farmer produce? What does he market? What kinds of crops does the fruit-grower raise? Does he market anything except fruit?

Problem 26. Are all the crops on your father's farm grown to sell or to feed? Are any grown to turn under to enrich the soil? What kinds? Why are these kinds better than others for this purpose?

Problem 27. Do all of the farmers have their busiest seasons at the same time of year? What is the busiest season on your father's farm? Why? Which kind of farmers have to work the greatest number of hours in the day — the dairy-farmers, the fruit-farmers, the stock-farmers, the grain-farmers, or the general farmers?

Problem 28. How many different kinds of plants are growing in your meadow? How do they behave together? Which ones seem to be leaders? How many kinds of plants are in the pasture?

Problem 29. Does your father mix two or more kinds of seed for any of his crops? What seeds does he put together? Why? How do the different kinds of plants share the ground when they are growing? Some of the crops that are sown together, as oats and peas, must be harvested together; others may be harvested separately. What makes the difference? How many companion crops can you name?

CHAPTER VII

THE FARM ANIMALS

When man was yet in a savage condition, he captured animals from the wilds and made them his slaves. He lived largely by hunting, and the meat of wild beasts formed much of his food. As he came to live a more settled life, he gradually hunted less and produced more of what he required. This made it necessary for him to domesticate wild creatures for work, for food, and, later, for clothing.

The source of farm animals. — When once wild beasts were domesticated, it was possible to develop from them new races that more nearly met the needs of man in a settled life. Thus, the earliest ancestors of all farm animals lived originally in the wild. They were different in appearance and usefulness from our farm stock to-day, which have been gradually brought into their present condition through years of domestication and care.

Nearly all our farm animals were brought to this country from the Old World. Most of them had been domesticated before the new era. The turkey is the only one domesticated from wild ancestors in America. The bison can be domesticated, and some persons are now endeavoring to develop a new race of useful farm animals from it. There are other wild beasts that some day may become part of our regular farm stock.

While there are many wild beasts that might be useful if domesticated, the number of kinds that have been domesticated is not great. Those common to the farm are horses, mules, cattle (oxen, dairy and beef cattle), sheep, hogs, goats, chickens, ducks, geese, turkeys, guinea-fowl, pigeons, silkworms, and bees. In the south-

western part of the United States there are a few ostrich farms. Occasionally a farmer will raise only pets for sale, but pets are not usually classed as farm animals.

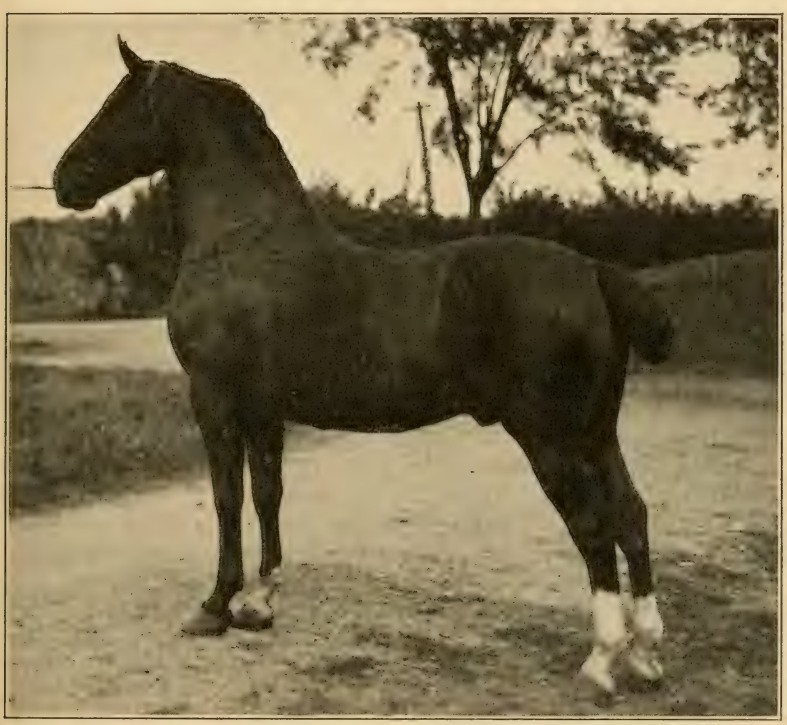

FIG. 15. — Coach horse. Animals may be developed for refinement and beauty as well as service.

Animals are necessary. — Live-stock is just as essential a part of the farm as are plants and crops. Animal food products, such as meat, milk, butter, and eggs, are equally in demand on the market with plant food products. It would not be possible to farm large areas if there were not animals to bear the burden of the work.

The savage used the skins of wild beasts for clothing before he learned how to weave, and to-day many of our finest and warmest clothes are made from animal products. Man has always enjoyed the companionship of animals, and some are raised only for this purpose.

Animals are reared for food. — If the human race had depended on hunting for its meat food, we should long ago have destroyed all

Fig. 16. — Jersey cow. Many generations of domestication and care have been required to bring farm animals to their present form and usefulness.

our wild animals and the demand would not have been satisfied. Large areas of land, great stores of crops, and the time of countless numbers of men are required merely to raise the live-stock necessary for food purposes. Nearly every farm keeps some stock, but to meet the demands great cattle ranches have been established on the western plains. Steers, sheep, hogs, and poultry contribute to the meat supply. Equally important, also, are their products, milk, cheese, butter, and eggs.

Many farm crops cannot be eaten in their raw state by man. When fed to the farm stock they are changed into a form in which he can use them. About 80 per cent of all the corn raised in the United States is fed to domestic animals. Hay and much of the grain and root-crops are made of use to man only by feeding them to animals.

For work. — The Indian in America did not make great progress because he had no beasts to do his work. It was not until animals

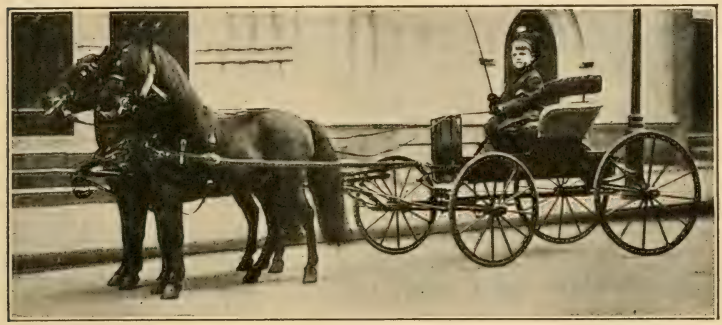

FIG. 17. — Animals are reared for pleasure and companionship.

were enslaved and trained to bear the heavy part of the work, that farming was possible on a large scale. The slow-going but steady oxen lightened the labor and made it possible to farm larger areas. To-day horse-power is used everywhere on our farms, and horses are a necessary part of the farm equipment. One horse, well directed, can do as much work as ten men.

For clothing. — The fur-bearing animals of North America meant as much to its early inhabitants as do all the flocks and herds of the present day to us. It was the chase and barter for their pelts that drew many of the earliest European adventurers across the ocean. We are still dependent on wild animals for some of our finer pieces of clothing. The fur of the beaver, buffalo, seal, opossum, raccoon, skunk, red fox, silver fox, rabbit, muskrat,

mink, marten, otter, ermine, bear, and others, secured by hunting and trapping, brings high prices in cities for clothing purposes.

Woolen goods are made from the fleece of our common sheep. The sheep industry, or the raising of fleeces for manufacture into clothing, is now one of the great farm industries in America. Mohair is made from the hair of the Angora goat.

There is another very small domesticated animal that helps to supply our clothing; that is the busy little silkworm. Its original home was probably in China, and China has long enjoyed a wide reputation for its fine silks. The early colonists in Virginia, South Carolina, and Georgia engaged in this industry to a limited extent, and since then a small amount of silk has been raised in this country. At the present time the United States Department of Agriculture is trying to encourage again the raising of silkworms in the southern states.

For soil fertility. — An old Flemish proverb reads:

"No grass, no cattle,
"No cattle, no manure,
"No manure, no crop."

This ancient proverb is just as true to-day, — there must be grass to feed the cattle, cattle to produce manure, manure to enrich the land so that more grass can grow. Without some kind of fertilizer crops cannot long be grown successfully. The farmer has learned by experience that if he raises crops year after year without enriching his land, the soil will lose its crop-producing power, and he will secure small returns.

One of the best means of keeping the land fertile is by spreading on it animal manure. Such manure is in a condition to be quickly used by growing plants. The farm boy knows that his father is careful to save all the barnyard manure for the land, and that he spreads it where he wants to raise a large crop. Farm animals are reared for the sake of our soils as well as for other purposes.

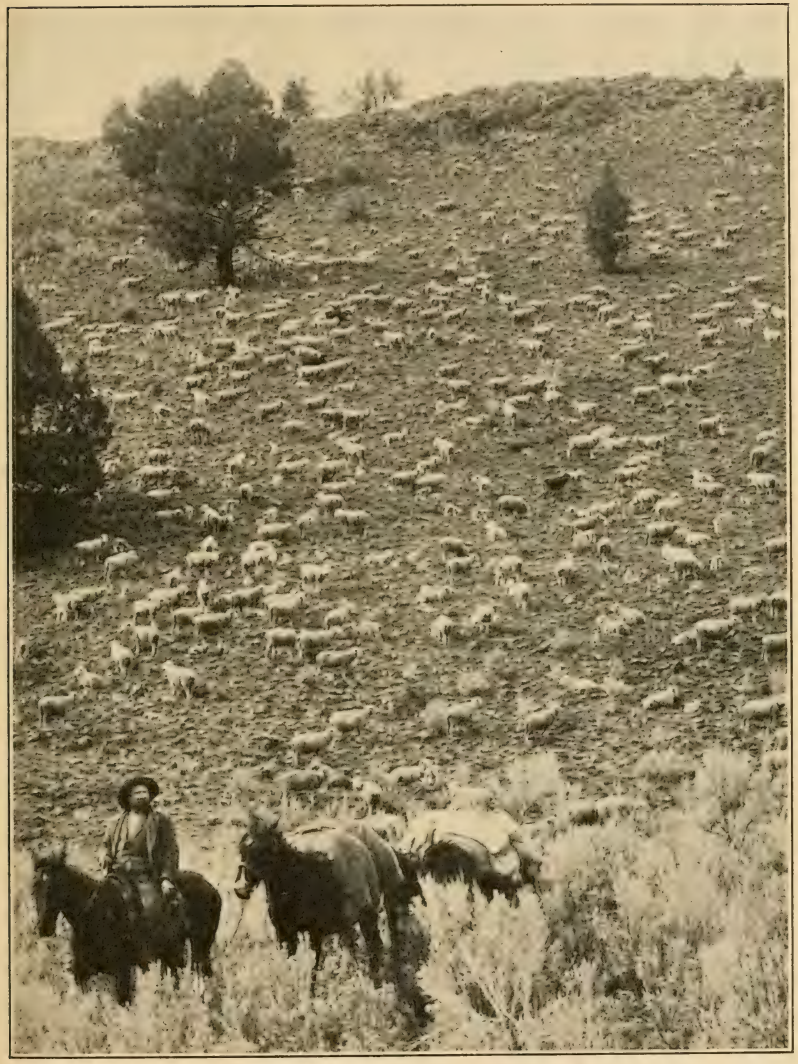

FIG. 18. — Sheep may be pastured where the plow cannot go.

Relation of animals to kind of farming. — The farmer who keeps live-stock organizes his work very differently from one who raises fruit or vegetables. He raises crops to be fed to stock, and he sells the stock or its products instead of the bulky crops. He must have large storage barns to hold his winter's feed. He markets his products at different times and in different ways from the crop-farmer.

The live-stock farmer can use land that otherwise might be wasted, that is not suited for growing crops, — land next to streams, or that is partially covered with trees, or that is too hilly or too stony to cultivate. Sheep may be pastured where the plow cannot go. Farm animals also use parts of plants that otherwise would be wasted, as straw, corn-stalks, and grasses.

A better rotation of crops, and consequently a better use of the land, can be had when animals are reared. More land can be kept in grass and clover, so that less plowing will need to be done; and the fertility of the land will be maintained by the return of the manure.

When live-stock is reared, the farm help is busy all the year; this is a mark of good farming. The exclusive wheat-farmer sows his grain in April and May (in the spring-wheat regions), harvests and threshes it in July and August, and has little work for himself, his men, or his teams the remainder of the year from September to April. The stock-farmer raises crops in summer, when the cattle are at pasture, and in the winter is busy caring for his animals when they must be fed indoors.

Problem 30. Is there any hunting in your locality? What do the hunters find? What kinds of game are used for food? Are any of them used only for clothing purposes?

Problem 31. How many kinds of animals are raised on your farm for food? How many for work? For clothing? For companions?

Problem 32. Do any of the farmers in your locality keep sheep? Where do they pasture them? What becomes of their products?

Problem 33. When does your father haul out his stable manure? Where does he spread it? Why? If he does not keep stock, does he buy any farm manure? Does it pay him to buy it?

CHAPTER VIII

THE FARMER'S AIDS

The American Indian lived such a simple, free life, living by hunting and a little planting, that he had need for few outside helps in his domestic life. The farmers in colonial days had their school and their church, but did not feel the want of many other aids. The farm was often the home, the store, and the factory, all in one. Farming meant little more than to clear the land and to raise enough to live on, with some surplus for near-at-hand barter. There was no world market to be reached.

Need of aids. — With the growth of towns and cities, with a division of labor, and the necessity for providing food-stuffs for the new nation, a need arose for special aids in farming and marketing. The complex life of to-day makes it necessary for the farmer to have many kinds of aids.

Kinds of aids. — As many different aids must be provided as there are special needs to be met. There must be schools and churches to encourage education and religion; good roads and railroads to enable the farmer to place his products on the markets; telephone and mail service; opportunities for comparing the farmer's products and skill with others, as in country fairs and exhibitions; and means by which the farmer can coöperate with his neighbors to do work in which all should have a part, and to bring them together for pleasure and visitation, as in farmers' clubs and the grange and the creamery.

The country school. — The school is one of the foremost aids that the farmer has, for his children must be well trained and be

able to think and to plan clearly and carefully if they are to make farm life and the farming industry as attractive and useful as it is possible to make them, and so that they will equal the best in city life. The schools help to develop the mind; and a trained mind that can meet problems and solve them is necessary if one is to be a good business man, a lawyer, an inventor, a mechanic, or a farmer.

Country schools teach boys and girls who live on the farm. They are now beginning to teach about the farming industry as well as other subjects. We are to study agriculture in our schools as well as history and arithmetic and grammar and geography. We need them all if the people are to be well educated. And we shall study advanced agriculture in the high-schools as well as advanced arithmetic and history and language. When we reach the college of agriculture, we shall receive special training in the affairs of agriculture so that we shall be expert in our work. Men have studied agriculture, just as they have studied law and medicine, and there is a great deal that may now be learned about farming by a systematic study of the subject. The farmer will find the school of increasing value to him in the future. If he once lived without special education, he can no longer expect to do so.

The country church. — Many of the early settlers came to America in order that they might "worship God according to the dictates of their own conscience" and "rear their children in the fear of the Lord." The church had an important part in the colonization of America, and, in some neighborhoods at least, the family that never attended church was the great exception. It established itself on the very frontier, a pioneer that amid great trials pointed the way to high standards of living and hopefulness. It has always been an important agency in farming regions, and to-day is found in every community. Good farming is only part of good living, and the church stands to inspire men to their highest character and usefulness.

Transportation. — The farmer is, of all men, most dependent on means of transportation, as the products that he raises must be placed on a distant market, and usually cannot be sold near home in any large quantity. In the early days in America, long-distance transportation was effected by means of water-routes and stage-lines; the turnpikes were few, the common roads almost impassable,

FIG. 19. — Water transportation of truck crops.

and stage-coach travel was costly and very difficult. With the coming of the railroad in 1830, new opportunities opened before the farmer, for then he could readily dispose of his surplus products. To-day the country is covered by a net-work of railroads and electric trolley lines, and there are great transcontinental railroads that speed the farmer's products from one end of the country to the other and place them on the market at just the right time. All this has made great changes in farming. Good means of reaching the markets are nearly as important as the ability to raise good products.

But railroads, trolley lines, and water-routes cannot reach all farmers, so that good wagon-roads must be provided. The farmer uses the wagon-road every day, going to and from the village, railroad station, or boat landing. If the roads are poor, he can haul less, it will take more time, cost more for teams and wagons, and altogether be expensive transportation. With good, well-kept roads, he can do his hauling quickly and easily. He will travel more, see his neighbors more often, and go to the village more frequently to get what he needs.

The telephone. — About twenty-five years ago the telephone was a curiosity and a plaything. To-day it is an indispensable means of communication. It keeps the farmer and his wife in close touch with their neighbors, so that they are no longer isolated, and they can become acquainted quickly with whatever is taking place in the community. The doctor can be reached without the long drive to the village; farm hands can be called together; if the thresher is to come to-morrow, the farmer in a few minutes can arrange with his neighbors for exchange of help, instead of traveling about all day to do so. The telephone can be used in all sorts of weather, at all times of the year, and at all hours of the day.

In some places the weather reports are sent to all farmers on the line at noon, and at six o'clock a general report on the conditions of the market. The farmer can then more readily plan his work for the next day, as he knows what weather to expect; and if he has a few tons of hay or a load of hogs to sell, he will know when to reach the market to get the best price.

Mail service. — Until within a few years, persons living in the country have had poor mail or postal service. To secure his mail, the farmer had to drive to the village, often miles away, frequently over poor roads, or had to depend on the slow stage route. He had either to neglect his work on the farm, and go to the village whether it was convenient or not, in all sorts of weather, or else go without his mail. Often he did the latter, and as a result was out of touch with affairs outside of his community. He wrote

few letters, for it was as hard to send them as to go after the replies.

In 1896 the United States government instituted rural free delivery of mails, and to-day most farming districts have this service. In 1908 there were about 40,000 carriers who reached 16,000,000 persons on farms, and the government spent $34,900,000 to render this aid to farmers. Now the farmer has his mail daily, may send and receive letters regularly, has his daily paper, and is in closer touch with the affairs of the nation. He is now in need of an extension of mail service by means of a post carrying large parcels as well as letters and journals.

The country fair. — The country fair is intended to be the place where the farmer may bring his best stock and crops for comparison with his neighbor's, where he may learn how to raise better products, see the latest farm machinery, and meet his neighbors for visitation and sociability. The fair was established as the farmer's holiday, when he should meet other farmers and show the results of his own work, and listen to addresses by leading men. To-day the fair in many country districts is not much help to the farmer, because a multitude of amusements and so-called attractions have crowded out his own part; but some day, when there are more grown-up boys and girls who know what a good country fair should be, it will be changed back to its original purpose and be a real help to the farmer.

It is interesting to know that as early as 1796 George Washington desired to see agricultural fairs held. A fair was held in Washington, D. C., on October 17–19, 1804, and was repeated in the following April, when premiums were offered. Soon after, other fairs and "cattle shows" were held throughout New England and in the middle states, and this kind of farmers' exhibition and social gathering became a regular occurrence.

Farmers' clubs. — The farmers' club, the agricultural society, and the grange represent still another kind of aid for the farmer. They offer him another opportunity to meet with his neighbors

and talk over farm and neighborhood questions. Sometimes the clubs establish telephone systems and fire insurance companies; sometimes they undertake to breed better animals or better crops in the locality, and to secure better machines; sometimes they help the farmer to buy his seeds and fertilizers, and to sell his surplus products.

The earliest farmers' clubs were formed about the same time that fairs were first held. Now there are many thousands of them. Nearly every farming community has at least one. When persons work together they are likely to secure better results than when they work alone.

The creamery. — Agricultural fairs and farmers' clubs are means by which farmers are able to work together and help one another. The creamery and the cheese factory are other important means of coöperation. They are useful in several ways. Farmers can send all of their milk there, and not have to manufacture it themselves; it is manufactured in large quantities, and consequently at less expense; the product is uniform, or just alike, from day to day and will sell better; it can be shipped in large quantities, and thus at less expense for transportation. Farmers can have their milk tested, so that they may know which cows are good and which are poor, and get rid of the poor ones. The creamery should teach cleanliness in handling milk, promptness, good business methods, and the principles of coöperation.

Public agricultural institutions. — The people maintain a Department of Agriculture at Washington as a part of the government of the United States (the chief of which is Secretary of Agriculture in the President's Cabinet), and a college of agriculture and experiment station in each state; and in most of the states there is a department of agriculture. In Canada, there is a Minister of Agriculture for the Dominion, and departments of agriculture in the provinces. There is a Dominion experiment station at Ottawa, with branch stations in the provinces. There are also several provincial schools and colleges of agriculture.

Problem 35. Are there any boys and girls in your school whose fathers or mothers went to the same school, or to the old one before this was built? Name all the leading and successful men who have studied in your school, so far as you can. Did their schooling seem to have anything to do with their success?

Problem 36. How long has there been a church in your locality? Ask your father whether he can remember any time when there was not. In what ways is the church useful in the locality?

Problem 37. How many different kinds of transportation does your father use in carrying his products from the farm to the market? Which kind costs the most? Ask your father to tell you how his grandfather marketed his crops.

Problem 38. Suppose your father lives eight miles from the station on a good state road, and John's father lives eight miles from the station on a poor road. If both men have to go to the station three times a week and it takes John's father, on the average, forty-five minutes longer each way to travel through the poor road, how much more will it cost him in six months (24 weeks), if the time of each man is worth 50 cents an hour? If John's father can carry only three-fourths as heavy a load each trip on the poor road, how many extra loads must he take to transport the same amount of stuff to the station as your father takes in six months? How much more will it cost him to do the same amount of work as your father will do in six months?

Problem 39. If in buying his farm on the poor road, John's father saved $1000, and put it in the bank at 5 per cent interest, did he make a good investment? How much money in the bank at 5 per cent interest would return the amount that your father saves each year in hauling? Your father's farm is worth at least that much more to him than the farm on the poor road.

Problem 40. How many families on your route have their mail delivered at the gate? If the first ten of them had driven to the village once a week simply for the mail, how many miles, all together, would they have traveled that week? How far did the carrier have to drive in making one delivery to the first ten?

Problem 41. Write a brief essay on the things you saw at the last country fair that would help the farmer in some way.

Problem 42. Explain what farmers' clubs or business organizations are in the locality, and what they do for the farmers.

Problem 43. Give the name and post office of the college of agriculture and experiment station in your state or province. Is there a department of agriculture?

PART II

THE SOIL

CHAPTER IX

WHAT THE SOIL IS

The very thin, soft covering of the earth in which plants grow is called the soil. The farmer tills the soil in order that plants may make better growth and give better account of themselves. It is marvelous that the soil can produce so many different kinds of plants.

The nature of soil. — If we take a handful of good garden soil, we find that it is mellow, dark-colored, and moist. If we place it in a dish and heat it, the moisture will be driven off and it will dry. If we heat it long enough, it will smoke a little, and we can see and smell that something in it is burning. This must be organic, or vegetable or animal matter, as mineral matter will not burn. We shall not see much change in size by the burning, which shows that there is little organic matter and that most of the soil is mineral. It is the organic matter, or "humus," as it is called, that gives the soil its dark, "rich" appearance, that makes it loose and mellow, and that holds much of the moisture.

If now we hold some of this mineral matter between our thumb and first finger, and grind it, we shall discover that it contains little particles of sharp grit, which are sometimes hard enough to scratch even glass if rubbed against it. If the soil is coarse and sandy, we can readily see these hard mineral particles; if it is a fine loam or clay, the particles can be seen under the microscope.

What the soil comes from. — It is evident that in some way mineral has been powdered to form the soil; and since the minerals come from rocks, it is the rocks that have been ground up. By

pounding up a rock we can make the fine, gritty, or mineral soil. When we grind the ax, we are adding particles to the soil, the particles being in part from the ax and in part from the grindstone, and they are drained off in the muddy water. The soil specialist, or geologist, can identify many of the soil particles as having come from certain rocks, as from sandstone, granite, limestone, or others. The particles are of different sizes. This is partly because they have come from different kinds of rocks, some of which are not usually broken up so fine as others.

Perhaps the bed-rock of the earth comes out on the surface of the ground in a nearby field; or there may be a deep cut somewhere near which shows the layer of rock under the soil; or maybe a well has been drilled on the farm and there was difficulty in getting through the bed-rock. Everywhere, we find, thesoil rests on the rock. In some places the rock shows on the surface, and in others it may be several hundred feet below the surface.

We read in our geography that at one time the earth was probably a white-hot sphere, like the sun, and that in time the outer part cooled and formed a crust or case of solid rock. It is the surface of this rock that has been changed into soil. If we could sweep off all the soil, we should come again to the rock-crust.

If we examine the soil in the woodlot, we shall find it light and loose, and to contain more or less decayed leaves, twigs, roots, and trunks of trees. In the garden, we may find parts of plants decaying in the same way and becoming part of the soil. It is evident, therefore, that the organic matter, or humus, comes from the decaying vegetable matter that falls on the soil, grows in it, or is plowed into it. Some of it is also formed by the death and decay of worms, insects, and animals, which are organic matter, and which must be returned to the soil when they die.

How the soil is made. — We have seen in the woodlot and in the garden how the organic matter gradually decays to form the soil. But how has the hard rock-crust all over this globe been changed into fine soil? There must have been some powerful means, or

agents. A close study of different kinds of soils will show that they have been formed by several means, chief of which are the sun, the

FIG. 20. — Year by year the forest adds its leaves, twigs, and decaying trunks to the soil.

air, water, plants, and animals. We shall study the work of each of these separately.

The work of the sun. — Most rocks are made up of fragments or particles of several sizes and kinds. As the sun beats down on a rock during the day, the rock is heated and expands. As the fragments are of different kinds, they do not all expand equally or in the same directions. Towards evening the air cools rapidly, and the rock also cools. Some of the fragments cool more rapidly than others, and we have uneven contraction. This uneven expansion and contraction, day after day, tends to make cracks, or crevices, in the rock, and even to chip off pieces. This kind of soil formation is most common in dry climates or where there are great extremes of heat and cold, as in New England and particularly in the mountain ranges in the west.

The work of air. — The air sifts into the cracks in the rocks and sets up a kind of rock-decay, resulting in the crumbling of the rock. In arid regions, or wherever the ground is not covered with grass, the wind lifts the particles of soil and hurls them against the rocks on hillsides, gradually wearing away the rock and undermining it so that it falls over. This is called disintegration. The rounded and dome-like shapes in the hills and mountains in the western desert regions are largely wind-formed.

The work of water. — The water from rains also finds its way into the little crevices in the rocks, where it may freeze and force the cracks to open wider. When ice forms in large cracks on hillsides, it may break large pieces from the rocks and send them tumbling down below.

The water also dissolves the rock, just as it dissolves sugar, but not so rapidly. The water nearly always contains a substance called carbonic acid, and this greatly increases its power to dissolve rocks. Very few rocks can resist the effect of such water. There is "no rock so hard, but a little wave may beat admission in a thousand years."

After a rain the creeks and rivers are always muddy because of the soil that the water has carried down from the hillsides. In the streams we may see pebbles that are being carried along on the

bottom, knocking against one another and rubbing off all the sharp edges so that they become smooth and round. The small particles that are chipped off are carried by the stream, together with the particles of soil from the hillsides, to the mouth, or where the stream

FIG. 21. — The bed of a stream at low water. Notice the pebbles that have been worn smooth by being rolled about. Tiny bits have been ground off to form soil.

overflows its banks, and there, where the water is quiet, are deposited as fine, soft mud. Perhaps we have seen this soft mud in the lowland where the creek has overflowed its banks during the spring freshet. Part of it is new soil ground from the rocks. In this way the deltas of rivulets, brooks, and rivers are formed.

The work of ice. — We have said that when ice forms in crevices in the rocks it forces them apart and may break off pieces. But ice has played a much greater part in the making of soils.

At one time the north temperate lands were covered by a great glacier that reached across the continent to the Rocky Mountains. At certain points it extended as far south as Pennsylvania, and in some places was a thousand feet or more in height. As this vast ice sheet moved gradually southward, it ground the rocks into powder, wore away the sides of mountains, and rounded off the hill-tops. It carried much of the soil and rock with it, and as it gradually melted, deposited its load by the way. With the melting of so much ice, great streams were formed, which carried away much of the finer soil and left the coarser and heavier sand, gravel, and pebbles as sand banks or gravel banks. Perhaps near your home there are such banks, left by the glacier, reminding you that it once occupied your region or farm.

Fig. 22. — A part of the edge of the Greenland glacier, showing its load of soil and rock.

There is now a glacier in Greenland covering an area more than ten times as great as that of New York State. It is slowly moving outward in all directions. From the ends that reach out into the sea icebergs break off, which, before they have melted, may float as far south as the path of ocean steamers. Similar glaciers are moving sea-ward from Alaska; and smaller ones are on many mountains.

The work of plants. — The roots of growing plants creep into the crevices in the rocks, and there increase in size, force the cracks wider open, and break off fragments. Decaying plants and roots hold the moisture of rains, and so form an acid which slowly dissolves the rock that it touches.

The work of animals. — All classes of burrowing animals, as the gopher, mole, woodchuck, and prairie dog, and of insects, as the ant, and the earthworms, help to form soil. They

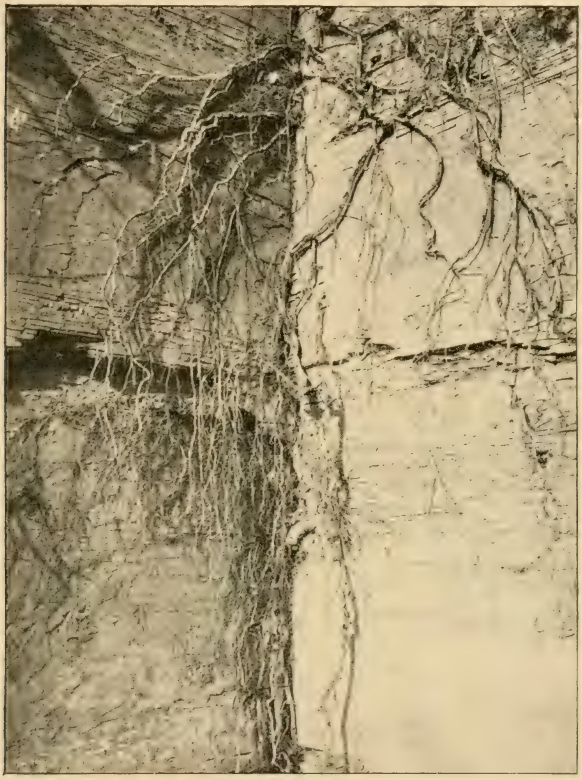

FIG. 23. — Roots follow crevices in rocks and help to make them larger. Then frost and water enter and split the rock.

keep it porous so that the rains can enter, and they bring the deeper soil to the surface. Those that eat the soil, as earthworms and certain insects, change its form. They are so

numerous in some soils that the part they take in soil-making is very important.

What soil is. — It is apparent, then, that soil is crumbled or ground up rock, containing particles of many shapes and sizes and materials, to which has been added decaying animal and vegetable material, which we call organic matter, or humus.

Problem 44. Ask your teacher to take the class for an excursion some afternoon, to study soil formation. Go to a creek or river-bank and describe the soil-making that is taking place there. Find a low place where the stream has overflowed, and note the fine, soft mud, which is still gritty. Then see whether you can find any crumbling rocks in the field or the fence row, or in a cut in a hillside. Chip off a piece of rock that has been exposed to the sun, and note the change that has taken place on the outside as compared with the inside. Ask your teacher to tell you what she knows about the formation of the hills, if there are any in the locality. See whether you can find a sand-bank or gravel-bank, and notice how it is formed.

Problem 45. Walk over your father's farm, or some other in your locality, and note carefully how many kinds of soil there are. Write an essay on what soil conditions you discover on the farm.

Problem 46. What difference is there between the soil in the woodlot and that in the hay field, in color, weight, texture, or feeling, and smell? Why is there this difference? Which contains the most moisture? Why?

Problem 47. Grind up three different kinds of rock as fine as you can and bring the fragments and powder to school for comparison. Is there any difference in the soil from the different kinds of rock? Which kinds of rock grind most easily? Which are hardest? Put all of the soil made by the pupils into a pot and set in it a growing plant. Keep it well watered and in a bright place. Will the plant grow in the soil you made? What is the chief difference between this soil and that in the field?

Problem 48. Heat some garden soil and note the changes. Heat some soil from the woodlot and note the changes. Which burns most? Why? Which changes most in size and color? Why? What has the heat done to each soil?

Problem 49. Why are some stones and pebbles rounded?

CHAPTER X

THE NATURE AND COMPOSITION OF SOIL

We have learned that there may be many different kinds of soils on the farm — one kind in the garden, one in the orchard, one on the hillsides, one in the lowland by the creek where the cows go to water, one in the woodlot; and perhaps on a neighbor's farm to the south there is a swamp with a still different kind of soil.

Fig. 24. — Hills formed by sand drifted by the wind.

There is one soil of New England, one of the prairies, one of the Mississippi bottoms, one of the great plains, and of the arid regions. They are different from one another, partly because different kinds of rock and vegetable materials have entered into their making, and partly because the soil particles are of different sizes and kinds. These soils have names, just as different kinds of

plants have names. The names help to describe them. Some of the names are peat, muck, clay, loam, sand, and gravel.

Peat. — If more than one half the soil is organic matter, or humus, it is called a peat soil. Peat is formed chiefly in swamps, where the water is quiet, and the mud which it carries settles to the bottom and furnishes a foothold for water plants. When these plants die, they are submerged in the water and others take their places. Year after year this process goes on, and there is built up a peat bog. Such peat bogs are frequently found in Canada, northern United States, Ireland, Scotland, and Norway. Peat may be dried and used for burning in place of wood or coal; all three of fuels these are organic matter in different forms.

Muck. — A soil that contains one fourth to one half organic matter is called muck. It is black and loose and holds a great deal of moisture. When a clay soil is plowed in the spring, the black muck can sometimes be seen in strips, or belts, along the hollows.

Clay. — A soil made up of such fine parts that one particle cannot be distinguished from another without the aid of a microscope, is called a clay soil. In the field it is stiff and sticky, and difficult to manage either when it is very wet or when it is very dry. It makes good mud pies, but they crack to pieces when they are dry. That is the way the soil behaves also in the field; we have all seen the cracked surface of the clay soil in the dry midsummer. A clay soil is frequently said to be *cold* because it holds water, that is, does not allow the water to pass through it readily. It is also said to be *heavy*, because it is closely compacted and sticky.

Loam. — A soil composed partly of clay and partly of sand is called a loam. If there is much clay in it, it is a clay loam; if much sand, it is a sandy loam. When clay and sand are in about equal proportions it is a true loam. This is the most common and most desirable type of general farm soil. It is easy to work, allows moisture to pass through sufficiently fast, and makes a good home for the plant roots.

Sand. — A soil so coarse that it is gritty is a sand soil. Its particles are much larger than those of the clay soil. They can readily be distinguished from one another. The soil is loose, open, and porous, allowing the water to drain out of it easily. Sand is therefore frequently spoken of as a "warm" and a "light" soil. We find sand soils along stream beds, along the shores of lakes, and in other places where the glacier deposited part of its burden.

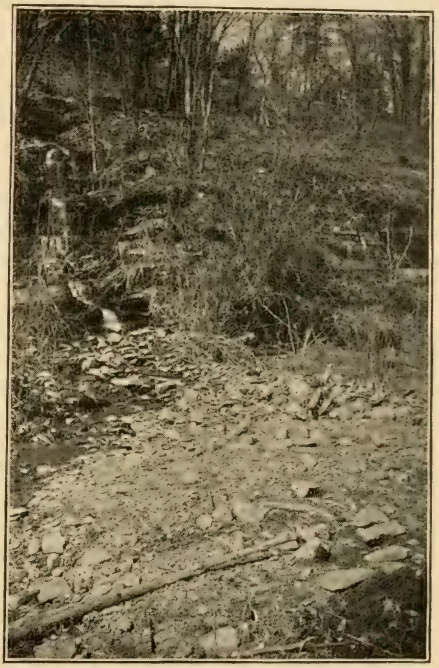

FIG. 25. — Where the current is checked the stream deposits its burden.

Gravel. — Some soils are nearly all gravel, or pebbles, and are called gravel soils. Others contain many large pebbles and small stones. A clay soil containing much stone is called a stony clay.

Weight of soil. — These several kinds of soils have different weights, which vary according to their denseness and solidity, or their openness and looseness. It has been determined that a cubic foot of sand weighs 100 to 110 pounds; of loam, 85 to 95 pounds; of clay, 65 to 80 pounds; of muck or peat, 45 to 70 pounds. Sand weighs more than clay, yet the farmer calls the clay a heavy soil, because it is fine and stiff and does not work easily, and the sand a light soil, because it is easily worked.

The physical composition of soil. — We now know that the soil

is made up of fine particles of rock, or mineral matter, of vegetable matter, water, plant and animal life. It contains also air, and another kind of plant life which perhaps we do not know about, because we cannot see it, but which is very important, — a low form of plant life called bacteria. The bacteria plants are so minute that they can be seen only under a strong microscope. Yet the soil could not produce plants if they were not there, changing it so as to make it useful for plant food. Some kinds of bacteria must have air in order to live, and so there must be air in the soil. We shall study in later chapters about these various materials that make up the soil.

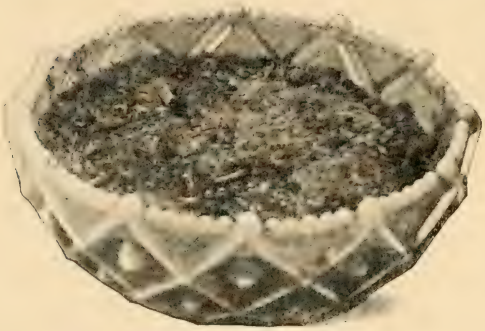

Fig. 26. — Soil that contains much humus and vegetable matter.

Importance of the physical composition of soil. — In order to grow, plants, like animals, must have food, air, water, and a suitable home. These are what the soil and the atmosphere supply. The suitable home must allow the roots to expand, supply the food which they are seeking, help to regulate the moisture and heat conditions for the plant, and give good support to that part of the plant that grows above ground. A considerable part of the plant grows below ground to support and nourish the part above ground. When we have tried to pull a pigweed out of a neglected part of the garden, we have discovered that the soil gives strong support, and that the root-anchor holds fast. The farmer recognizes the importance of the physical conditions, and plows and fits his land carefully.

Soil as a source of plant-food. — The plant needs a variety of food, just as the hungry boy does. Many different substances, or

elements,[1] are required for its growth. The tissues are formed from carbon, hydrogen, oxygen, and nitrogen, and small amounts (less than 5 per cent in all) of mineral elements. The carbon, hydrogen, oxygen, and nitrogen are secured from the air and from the water in the soil. The mineral elements, potassium, calcium, sodium, magnesium, iron, sulfur, chlorine, and phosphorus, are secured from the soil. They are used only in small amounts.

These mineral elements exist in the soil as compounds,[1] or chemical mixtures. In order to be usable by plants, they must be dissolved in the soil water. Through the roots they can then pass into the plant, where they are prepared by a process of digestion for its special needs.

Substances called silicon, aluminum, and oxygen make up 80 to 90 per cent of the mineral matter in soil. As the plant gets its oxygen from the air and water, and seems to require very little or no silicon, the greater part of the mineral matter in soil is of no use except to give the plant support.

Relation of soil to farming in the locality. — The kind of soil determines to a considerable extent the type of farming that shall be done in the locality. Some crops can be raised on a great variety of soils, while other are not so easy to please. Timothy hay will grow successfully on clay, clay loam, loam, and even fine, sandy soils; apples, pears, and grapes prefer heavy loam or clay soils, and peaches prefer sandy soils.

When peat and muck soils are well drained, they are excellent for growing onions, celery, cabbage, and peppermint. Extensive growers of these crops usually choose such land if they can secure it. Where there are belts or stretches of muck land, the farmers grow only one or two crops; here, the soil determines the kind of farming. Clay soils will produce good crops of hay, wheat, oats, beets, cabbage, and turnips. They are too cold and wet for

[1] An *element* is a substance composed of only one kind of matter. Carbon, nitrogen, and potassium are elements. A *compound* is a substance composed of two or more kinds of matter, or elements. Sodium nitrate and copper sulfate are compounds.

corn and too stiff to allow potatoes to grow freely. Loam soils produce hay, wheat, and oats nearly as well as clay; they produce corn and clover better than clay. Potatoes, tomatoes, beans, and peas do very well on loams. Sandy soils produce poor crops of

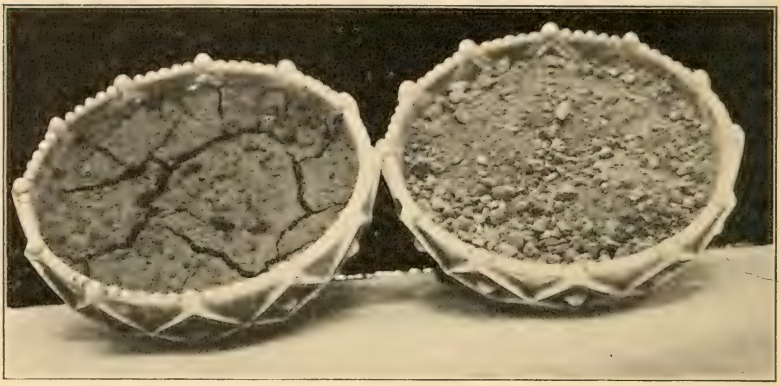

FIG. 27. — Two soils. On the left, clay that has dried and cracked; on the right, a loose loam.

grain and grass, but because they are warm are well adapted for growing berries and early vegetables, as peas, radishes, and lettuce. The intelligent farmer will adapt his crops to his soils.

Problem 50. Ask your teacher to take the class for another soil excursion. Some one take a spade. In the meadow, dig down about eighteen inches into the soil. Is there any difference between the surface soil and the under or subsoil? Which is looser? Which is darker colored? Which has most organic matter? Why? How deep down is the subsoil? How many factors have helped to make the surface soil different from the subsoil? Take a bottle or glass full of both surface soil and subsoil for study and exhibit in the schoolroom. Put a label on the glass to show where and when the soil was secured.

Make a similar study of the soils in the woodlot and down by the creek bed, if there are woods and creeks in your neighborhood.

Problem 51. Make for the schoolroom an exhibit or museum containing muck, clay, loam, sand, gravel, and stony clay soils. Mark the bottles

to show where each was found. Get the same amount of each kind of soil, weigh the samples, and mark the weights on the bottles. After a few weeks, note which have changed most. Weigh them again. Explain the changes.

Problem 52. What kind of soil is most common in your locality? Do all of the farmers grow, in general, the same kinds of crops? Are there any special crops? Are the special crops grown on certain kinds of soil? Does your father try to adapt his crops to the different kinds of soil on his farm, if there are differences?

Problem 53. Write a short essay about the part that the soil plays in the growing of plants — what it does for the plant, and how.

CHAPTER XI

THE SOIL WATER

If a soil is perfectly dry — or as dry as you ever saw it — it cannot raise plants. When we add water, we see that plants will grow, or they will revive if they are wilted. We know that in some way the soil water is useful to plants.

Relation of water to plant growth. — A living plant contains a large proportion of water — generally more than 75 per cent of its weight. Practically all this water is taken from the soil by the roots. All growing plants need water, first, because they can take their food from the soil only in liquid form, and second, in order to keep fresh — that is, to keep their cells expanded or turgid, the opposite of wilted. The soil moisture is the immediate source of the food-supply of plants; it is a plant-food itself, and it carries other plant-foods. Much water must pass up through the plant in order to carry the food to the leaves.[1] From there the surplus water is then evaporated or " transpired " into the air.

How the water gets into the soil. — If we go out immediately after a shower, we find little muddy streams running by the roadside; out in the corn-field, where the land slopes down toward the hollow, some of the soil has been washed away, and the heavy rain has cut deep channels toward the bottom of the slope. The little rills rise rapidly and rush away, loaded with fine soil from the plowed fields.

[1] It has been found that crops take 300 to 500 tons of water from the soil to make one ton of dry plant substance, which includes all of the plant except the water. Timothy hay takes 300 tons of water to make one ton of dry hay. Oats require 500 tons, barley 464 tons, clover 576 tons, potatoes 385 tons, to produce one ton of dry matter.

But not all of the water robs the land and retreats with haste to the nearest creek or pond. Much of it does not stop when it

FIG. 28. — Disastrous soil erosion, or washing, in an orchard.

strikes the surface of the ground, but sinks into the soil through the cracks, crevices, earthworm burrows, channels left by the decay of roots, and whatever other openings there may be. As it is urged on by other water from above, it will sink down to the lower layers of soil until finally, if the rain is heavy enough, it will reach the level of the "free" water, from which wells and springs are supplied. Very heavy and long-continued rains may fill the upper layers of soil with water. Dashing showers will run off the surface, if it slopes, as time is required for water to soak into the soil. When the land is dry, the farmer likes a slow, steady rain that continues for several hours — a soaking rain.[1]

How the water is held. — As the water passes downward, each particle of soil surrounds itself with a thin film or coating of water, much as does a marble when dipped into water. All through the soil are holes or pore spaces, which vary in size with the kind of soil. In a fine-grained soil, as clay, which packs closely, the spaces are small, and the water cannot pass through quickly. Much water is held back in the little cavities. In a loose, coarse-grained soil, as sand, the spaces are large and the water passes through very rapidly. We might compare the two types of soil with two pieces of cloth — one of fine linen and the other of cheese cloth. The former, with its fine spaces, will almost hold water, while the latter, with its large openings, allows it to drain through rapidly.

The area of the surface of a single lump of soil is not so great as the total area of the surfaces of all the separate particles into which it may be ground. (See Problem 5 on page 5.) Therefore a coarse, lumpy soil does not hold so much water in the form of films about the soil particles as does a clay soil. The moisture conditions are right for plant growth when each soil particle has

[1] It is interesting to know that in dry weather the soil has the power of taking from the air at night, even when there is no dew, some of the moisture that has been evaporated during the hot day. It has been determined that a stiff clay in one night may absorb moisture from the air equal to one-thirtieth of its weight. A dry peat or muck may take one-twelfth of its weight. Sandy soils absorb little in this way.

a film of water on its surface. If there is more water, so that the pore spaces are filled and the soil is saturated, the conditions are not good for the growing of plants.

Perhaps we shall now understand why clay is frequently a sticky, wet soil, and forms puddles on the surface after a rain, while sand is a dry soil and almost never puddles.

How soil water moves. — Water which sinks deep into the soil and supplies springs and wells is called "free" water. It moves freely through the open spaces. That which is held as films about soil particles is called "capillary" water. The movement of the capillary water is of the greatest importance to the farmer.

Since the soil particles which make up the soil are in contact with one another, touch one another, the film on one particle is in contact with the film on another. Films of water are found also in the angles or joints where the particles are in contact. Thus there is established a chain of films, which reaches down into the soil from the surface. When the hot sun shines after a rain, the capillary water in the upper layers is evaporated into the air, and the surface of the soil tends to become dry. Then, by means of this chain, the capillary water from below is lifted to take the place of that which is evaporated, or has been used by plants; a current toward the surface is created.

Since the soil particles are in contact with one another on all sides, the capillary water can move horizontally, or sidewise, as well as downward or upward. The movement is generally from a moist area toward a dry area. In the dry growing season the movement is largely upward or sidewise. In fine soils, in which the particles are small, the chain is stronger, and the upward lift of capillary water is greater, than in coarse soils having large particles.

Drainage. — In humid regions, enough water falls to more than completely fill the pore spaces in the soil. If moist soils did not provide some underdrainage, all lands, even the most rolling, would be swampy. More water must be removed from the soil than runs

off the surface. All lands that do not have natural underdrainage must be artificially underdrained. Surplus water in the pore spaces and excess water at the deeper levels must be removed in order

FIG. 29. — This soil needs drainage. After rain it puddled. Then, when the sun shone, it "baked," or dried, until it cracked.

that air may enter and that there may be a larger feeding area for plant roots. Plant roots will go down only as far as air can penetrate.

Drainage has other uses than merely to remove surplus water and admit air, thereby giving the roots a larger feeding place.

FIG. 30. — Young apple orchard prepared for irrigation.

Water makes the ground cold. When it is removed, the ground warms up earlier in the spring and crops can be planted earlier. Plant food is more available in well-drained soils. Wet soils are likely to be sour or acid, and not well adapted for the growing of many kinds of plants. If the ground heaves in winter, breaking the plant roots, it is an indication that drainage is needed. Drainage will largely prevent heaving. It will also largely prevent the "baking" or cracking of soils in midsummer. It really provides more moisture, not less, for plants, because it removes only the harmful excess and allows the roots to go deeper and so to be in contact with more capillary water.

The best means of artificially draining most lands is by laying tile drains in the soil three to five feet deep, and close enough to take care of all surplus water. When it is necessary to remove only excess surface water, open surface ditches may be used.

Irrigation. — Sometimes soils do not receive enough water, or it is not well enough distributed throughout the year, to meet the needs of growing plants. In such cases water must be supplied artificially. In many large areas in the western part of the United States no farm crops can be grown unless the land is irrigated. In other regions, the rainfall is not sufficient for good crop growth. Fifty years ago less than 100,000 acres in the United States were irrigated. To-day over 10,000,000 acres are being irrigated. Many more millions will be productive when they are irrigated.

In the east, irrigation is also being practiced by farmers who grow vegetables or truck-crops for market. Their crops may be ruined if they depend wholly on natural rainfall, and they sometimes establish systems of irrigation in their vegetable gardens.

In the great western irrigation systems, immense dams are built to form reservoirs or artificial lakes, to hold back all the water from rains and winter snows. From these reservoirs, canals carry the water through the region to be watered. Ditches opening from the canals distribute it to the fields. In some places canals and

FIG. 31. — These plants have wilted because of too much water, causing a lack of soil air.

ditches run back from rivers, and reservoirs do not have to be built.

Relation of water to soil temperature. — We have already learned that much water makes the soil cold. This is because it takes five to eight times as much heat to raise the temperature of water one degree as to raise the temperature of dry soil one degree. It also takes a great deal of heat to evaporate excess water from the soil. A wet or moist soil is therefore much more difficult to warm than a dry soil.

Growth will not begin in most cultivated crops when the temperature is below 40° F. Above this temperature, growth conditions improve up to a given temperature, beyond which they fall again from too great heat. Corn will not begin to grow below 48° or 49° F. It grows best at 93° F.

Problem 54. Fill a four-ounce medicine bottle with well water. Cut a small slip of geranium and put the lower end into the water. Hang the bottle containing the slip in the window. Empty the water every other day and fill the bottle with fresh well water. Does the slip grow? Does it have food? Where does it get its food? Is there dissolved mineral matter, plant-food, in the well water? Do you suppose that your well is simply a deep hole to catch the excess soil water, which contains plant-food?

Problem 55. Take three long-necked lamp chimneys or glass tubes, and tie a piece of coarse muslin over one end of each. Fill one with coarse sand, one with sand and loam mixed, and one with clay, to within one and one half inches of the top. Jar carefully to compact the soil while filling. Stand the tubes in trays filled about two inches deep with very coarse sand or fine gravel. Fill each tube to the top with water. As the water sinks, add equal amounts to each tube. In which tube does the water sink fastest? In which one does it drain away from the bottom first? When each has begun to drain, fill each tube level full of water at the top and see how long it takes each to lose its one and one half inches of water. Keep the tubes for a few days and note which one dries first and which last.

Problem 56. Are there any surface drains on your father's farm, or on any farm in the locality? Are there any underdrains? Are there wet places on your farm? What kind of soil is there in the wet places? How does it behave when it is dry?

Problem 57. Write a short essay about what becomes of the rain that falls on your father's farm.

Problem 58. Inside a circle three inches in diameter we can draw seven circles each one inch in diameter, and have considerable space left. What is the circumference of the three-inch circle? What is the total circumference of the seven one-inch circles? Suppose we filled all the remaining spaces with small circles; would we add greatly to the total circumference of all the circles within the large one? This shows that particles in a fine soil have much more surface area to hold water than particles in a coarse soil.

Problem 59. Where is the great Roosevelt dam? Why is it there?

CHAPTER XII

THE SOIL AIR

It is easy enough to see that there must be moisture in the soil if plants are to grow, but perhaps we had not thought it is just as necessary that there be air in the soil. Perhaps we did not know that air can get into the soil at all.

Relation of soil air to plant growth. — All plants require air around their growing parts, around the roots as well as about the stems and leaves. A soil is not in the best condition for the production of crops unless there is, within its depths, a free circulation of air. This is true because oxygen in the soil is as necessary for the life of the plant as oxygen in the atmosphere is for the animal. We could not live without the oxygen which we breathe from the atmosphere.

If there is not free oxygen in the soil, that is, oxygen not combined with other elements, seeds will not germinate, or will not begin growth, but will rot. Neither can roots do their part. The great host of soil germs or bacteria, whose work it is to make certain plant-foods available, will perish if they cannot have air. In other words, all activities in the soil that have to do with the growth of plants will cease if air is not present.

Nature of soil air. — The air in the soil has a somewhat different composition from that above ground. As a rule it contains less oxygen and more carbonic acid, ammonia, and vapor of water. It receives large amounts of carbonic acid and ammonia from the decay of humus in the soil. The carbon from carbonic acid is a plant-food.

The particular composition of soil air makes it specially useful in plant growth. Carbonic acid, which is taken up by the soil water from the soil air, aids greatly in dissolving the mineral matter in soil and fitting it for the use of plants. It unites with other elements in the soil to form carbonates. These are compounds, or storehouses, of plant-forming materials not needed at the time, but to be used later.

Fig. 32. — The roots of the cowpea, showing the nodules in which live the bacteria that gather nitrogen.

Where soil air is. — The air cannot occupy the space that is occupied by anything else. It therefore circulates in the open spaces or pores of the soil. If these spaces are filled by water, the air is driven out, and plants cannot grow. In order to ventilate such soil, that is, to admit air to it, it must be drained and the excess water removed. Proper drainage will lower the free or ground water three or four feet. The air can penetrate until it reaches the free water. This makes it possible for roots to reach way down and thus escape the effects of dry weather. When deep roots die and decay, they leave passageways through the lower layers of soil for the circulation of air and water.

How soil air gets there. — From what we have already studied, we know that air gets into the soil through the pores, and through cracks, crevices, and passages made by earthworms or decayed

roots. There are other ways also. When the rain water seeps into the soil, it carries air with it. When water drains away from the soil, or is carried upward by capillarity or tension and is evaporated, or used by plant roots, it acts by suction to draw

FIG. 33. — A good earth mulch holds the moisture, even in dry seasons, and allows air to enter.

as much air into the soil as there has water passed out. When the wind blows over the soil, it creates a suction that draws air into the soil.

The farmer introduces air into his soil by plowing, turning the soil over, exposing it to the air, and making new pore spaces.

Problem 60. Put clay soil in a pot and plant seeds. Wet the surface of the soil and puddle or pack the clay while wet. Watch for the seeds to germinate and grow. Keep the pot soaked. At the same time put seeds in another pot filled with loose, mellow, moist soil. In which do the plants first appear? Why do not the plants grow in the first soil?

Problem 61. If there is a bare place on your father's farm, or on a neighboring farm, try to find out why it does not produce plants. Might one reason be that it is so hard that air cannot enter?

Problem 62. Why does very little grass grow on the playground by the schoolhouse during the summer vacation?

Problem 63. Why do seeds rot in a water-soaked soil?

Problem 64. Do you suppose that you could cause seeds to germinate even in a water-logged soil if you thrust straws down to them?

CHAPTER XIII

PLANT LIFE IN THE SOIL

The kinds of plant life to be considered in this chapter are not the roots of plants, but lower and simpler forms that we call fungi and yeasts and bacteria; sometimes we call them all simply "germs." We seldom think that the soil is teeming with countless millions of invisible plants which are busy making possible the growth of the higher plants.

Fungi differ from yeasts and bacteria. They are not always invisible and may grow above ground. Molds, mushrooms, and toadstools are fungi.

Yeasts are always tiny, invisible plants that can be seen only with the aid of a microscope. They are more abundant near the surface of the ground.

Bacteria are the smallest of all the germs, and are the smallest living things. They are the most active in the soil in the farmer's behalf, and we shall study them especially.

How germs live in the soil. — These invisible plants do not require sunlight. That is one reason why they can live in the soil. They do require plenty of organic, or humus, food and an abundance of water. As dry sandy soils contain little water or organic food, these little plant organisms are less numerous there. In moist soils they are always found. The soils must not be so moist, however, as to be cold, for these tiny plants demand a comfortable temperature. Most of them are found in the first six inches of soil.

Fungi are most numerous where there is a great abundance of vegetable matter in the soil, as in the forest. Yeasts gather wherever there is much sugar in the soil — not table sugar as we

know it, but compounds made up of much the same materials. Bacteria thrive where there is proteid matter (containing much nitrogen). Proteid matter is found wherever any animal or vegetable substance accumulates. Animal remains and manures are rich in proteids. In the barnyard and the manure heap bacteria exist in very great numbers, even as great as 100,000,000 in one gram of soil (a gram is .002 of a pound).

What the germs do. — These germs simply live their lives in the soil. They grow, reproduce new germs, and die. But in this round of their lives they are of great value to the farmer.

All plants and animals require food. Much of it is limited in quantity. There is little plant-food available in the soil at any one time, yet plants and animals have used food constantly for unknown centuries. And our soils are still producing plants. This is possible because the same food is used over and over again. One kind of living things uses the food and in so doing changes it into a form to be used by another kind of living things. The food elements or substances pass through a circle or cycle, constantly returning to the form in which they started.

Plants must be grown to feed animals. All tillage of the soil is to help plants to grow — to make the food in the soil available for plants. When the plants consume this food, they change it into a new form that cannot be used as food for plants. But is then just the right form for animals, and so animals consume the green plants. In the animal body the food compounds received in the plants that are eaten are again changed. Some of the compounds are returned to the soil in the manure. All of the others are returned when the animal dies and is buried.

When the food materials, which came originally from the soil, have passed through these several changes and are returned once more to the soil, they are not then in a form to be used again by plants. This is where the germs in the soil do their part. Each of the three kinds goes to work. The fungi attack the vegetable tissues for their food. The yeasts revel in the sugars

and starches, which are found in both plant and animal tissues. The bacteria act on all organic materials, but chiefly on the proteids. By the combined action of all three, the entire dead plant or animal is changed into simpler forms again. Without their aid the soil would soon become clogged with the dead bodies of plants and animals, and be useless for vegetation.

But these germs do their work so well that many of the materials are changed into forms too simple to be used by plants. Nature is equal to this emergency, and has provided another class of soil organisms or germs to feed on the simple elements and change them into forms which are just right for plant-food. And there the foods start on their journey again.

This circle, or cycle, of life, in which all living things have their part and receive their nourishment, helps us to understand why the soil can produce crops for countless centuries. It is only when the farmer takes so much food from the soil in crops and returns nothing to it, that the cycle is broken, and soils become poor and unproductive.

It is thought that some kinds of bacteria act on the mineral part of soil, just as others work on the organic part. They aid the processes which we studied in Chapter IX in making the mineral foods available to plants.

The formation of nitrates. — One of the most important plant-foods is nitrogen. In its pure state it cannot be used by plants and must be changed into a particular form, or compound, which we call nitrate. The nitrogen is made into nitrates by the soil bacteria, which secure their nitrogen from the decaying organic matter, and from the air. This decaying organic matter may be vegetable remains, as roots, stems, and leaves, or animal manures, or dead animal bodies. By the action of several kinds of bacteria, each of which fits the material for the food of the next, the nitrates are created.

Another activity. — Every farm boy knows that the fields are richest where clover has been grown. Certain crops, which we call

legumes, such as clover, alfalfa, beans, peas, cowpeas, and vetches, leave the soil in a specially rich or fertile condition. The soil bacteria must be given credit for this unusual richness. Nature has provided a class of bacteria that penetrate the small rootlets and set up nitrogen factories, which we call root nodules. In these factories, which are established only on legume plants, nitrates are made and stored for the use of the plant itself and for other plants that will be grown on the soil after the legume is harvested. Because legumes carry so much nitrogen, they are valuable cattle foods as well as soil-enrichers.

Soil inoculation. — Sometimes it is desirable to place these tiny plant organisms in soil in which they are lacking. This operation we call soil inoculation; that is, we inoculate, or infect, the soil with bacteria. Soil inoculation may be practiced when a new legume is to be grown on the land. It is most easily done by spreading on the land soil from a field where the same kind of legume has grown successfully. The soil carries the bacteria, and thus they get into or inoculate the new soil. If clover does not do well on one field, but thrives on another, it may be made to grow better on the first by sprinkling on it some soil from the second.

Soil diseases. — There are some kinds of invisible plant life in the soil which are not desirable. They are plant disease germs. They are just as active in the soil as the helpful kinds of germs, and may cause the farmer great loss. Clubroot of cabbage is a soil disease.

Problem 65. With a spade, go into a field in which a heavy sod or stubble was plowed under last spring or last fall. Dig up some of the soil and note what changes are taking place in the vegetable parts that were plowed in. If possible, find next a field in which vegetable matter was plowed in the year before. What has become of the vegetable materials in this field? Then go over to the woodlot, and where the trees are thickest dig down about fifteen inches. Describe the changes in the condition of the soil as you go down from the surface. What is most of this soil made from?

Problem 66. Can you find any mushrooms or toadstools in the woods or about the barn? Why do they grow there?

Problem 67. Carefully pull up a clover, sweet clover, alfalfa, or some other legume plant, and look for the little nodules or swellings on the roots. They may be as small as pin heads, or much larger. Try to find them on the roots of two or three different kinds of legumes for comparison. Wash the roots carefully and keep them for a while in a glass jar in the schoolroom for observation.

Problem 68. Legumes are the true pod-bearing plants. The pea-pod is the kind of fruit that botanists call a "legume," and from this the name has been given to all the plants of this family. It is a large family. Most of them have pea-shaped or butterfly-like flowers. How many kinds of leguminous plants can you name?

Problem 69. Write a story about the life cycle of a corn plant — what becomes of the plant and how the materials that are in it are carried round to go into another corn plant.

CHAPTER XIV

THE TILLAGE OF THE SOIL

TILLAGE is the stirring or turning over of the soil to fit it for the growing of plants. Plowing and spading and harrowing and hoeing are forms of tillage. Land is tilled in order that crops may be planted and harvested, and to improve the condition of the soil so that it will yield the largest and best crops.

When man first tilled the soil, centuries ago, he doubtless did it only to get his seed into the soil, or, in the case of root crops, to get

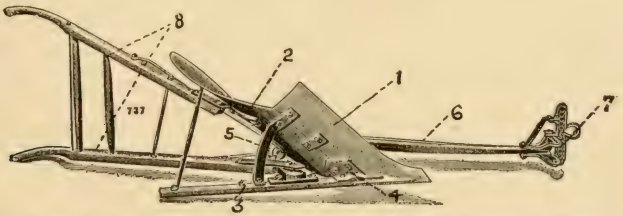

FIG. 34. — Bottom view of a modern plow, showing the parts. 1, share; 2, moldboard; 3, landslide; 4, frog; 5, brace; 6, beam; 7, clevis; 8, handle.

the crops out of the soil. Gradually it was learned that tillage had other uses — that it destroyed weeds, and that stirring the soil to remove weeds seemed to make the plants grow better. When the land did not produce good crops, the workman thought that it needed to have a rest instead of more thorough tillage. So he rested his land for a year, or "fallowed" it, as we say to-day; that is, he allowed it to remain idle.

History of tillage. — In the early part of the eighteenth century, Jethro Tull, an English landlord, began to teach that tillage is

the most important farm operation. He declared that by tillage, which would make the soil fine for the use of plants, soils could be kept forever in a productive condition. He thought that the plants took the fine particles of soil themselves into the roots and digested them within the plant. He did not know, as we do to-day, that plants cannot take in solid materials, but must get their food from the soil in liquid form. He did know, however, that thorough tillage made the plants thrive, even though he did not know the true reason. Tull's teachings and writings completely changed the methods of farming of his day. Thereafter tillage occupied a more important place in farm operations.

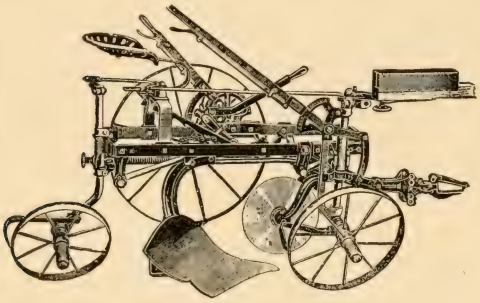

FIG. 35. — Sulky plow.

We shall learn in this chapter some of the reasons why the farmers of the present day till their soils.

History of tillage tools. — The first tools for stirring the soil were for hand use. They were built after the fashion of the hoe. Later, crooked sticks, so shaped as to enter and loosen the soil, were used to draw behind the workman. This seems to have led to the development of the plow. The first plows were either pushed or drawn by man. The ancient Egyptians built and used a plow that had a beam, a shank, and a handle, and they used their animals to draw it. From this the next step was to provide the wearing parts with a shoe of iron. This was done very early, for it is written, 1100 years B.C., that the Israelites, who had little skill in the working of iron, "went down to the Philistines to sharpen, every man, his share and his coulter."

From the first appearance of the plow to the present, many

changes and improvements have been made, and several thousand different models, or types, have been designed at various times. At present there are very many kinds in use, from the single walking plow to the large steam plows that carry gangs of sixteen to

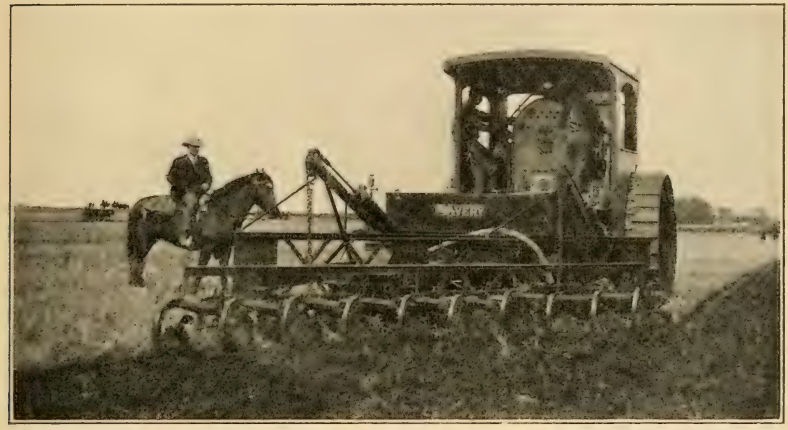

Fig. 36. — Gang plow, drawn by traction engine. Used for large area farming.

twenty plows. These large gangs will plow, harrow, and occasionally seed, in one operation, 40 to 60 acres in a day. The development of this implement has a long history, and in one form or another it has had a part in the development of all nations and races.

Next to the plow, the harrow is perhaps the oldest tillage tool. The first harrow was doubtless the limb of a tree with extending branches. From this developed the first type of harrow, a forked stick with spikes in each arm. Later a cross-arm was added and we had the " A " harrow. The Romans used a square or oblong harrow with cross-bars carrying many teeth. Our modern harrows all follow these same general principles.

The first rollers were carefully chosen logs. Spikes or bars were driven into the ends and a yoke provided for drawing. This style

of roller was in use until within recent years. Because of difficulty in turning, the two-piece or two-section roller was devised. There are now both smooth and rough, or ribbed, rollers in use.

The earliest cultivator was a sort of crude hoe, with at first a single shovel. This gave way to the double shovel and the use of animal power. From the latter was developed the straddle-row

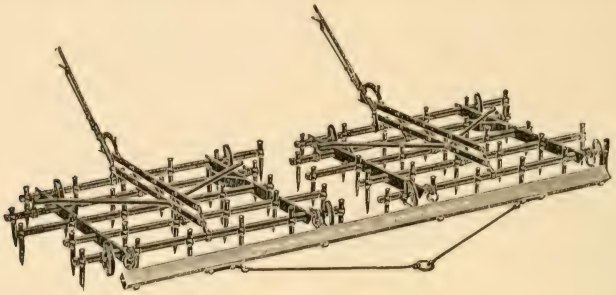

Fig. 37. — Spike tooth harrow.

cultivator, to stir both sides of a row at one time. The double shovels, used in this country until 1860, were usually made by country blacksmiths. On April 22, 1856, George Esterly patented a straddle-row cultivator, and began the manufacture on a large scale.

Why soils are tilled. — We have already learned that plants will not grow unless their roots have a suitable home and feeding ground. An important factor in creating this suitable home is to have the soil in good physical condition; that is, to have good soil texture. Tillage is the best means of improving the texture of soil. The following are some of the reasons why soils are improved by tillage:

(1) Tillage makes the soil finer and deeper, so that roots can reach farther.

(2) It turns up the moist soil in spring and enables the surface to dry enough to make a good, early seed-bed.

(3) It helps the soil to hold a larger amount of useful moisture by fining or pulverizing it.

(4) It saves moisture in the hot midsummer.

(5) It stirs the soil and allows air to enter.

(6) It prevents the growth of weeds, which take plant-food and moisture from the soil.

(7) By tillage, vegetable matter is plowed into the soil to make it more productive.

Tillage makes plant-food available. — There is a great deal of material in the soil that will serve as food for plants when it is changed into some other form. Plant-food is available only when in a condition in which plants can use it. A man locked up in a barn full of wheat might become weak from hunger. Yet there is food enough near him to feed several hundred men if only it were in the right form. There is as much plant-food in the first sixteen inches of an acre of average soil as can be bought in fertilizers for $2000. It is the purpose of tillage to save the $2000 for the farmer and enable him to get his plant-food directly from the soil instead of buying it.

As we have learned in the preceding chapters, moisture, heat, and air are necessary in the soil if the minerals are to be dissolved, the organic matter decayed, and the bacteria do their work. All of these activities must take place in order to prepare the soil as food for plants. Tillage opens up the soil to receive moisture, heat, and air. It is therefore of first importance in creating the right conditions for the growth of plants.

Tillage saves moisture. — Tillage, if it is well done, breaks the soil into very fine particles. We know that a soil made up of fine particles will hold much more moisture than a coarse one. As we have already learned, the moisture is in the form of thin films about each of the soil grains, and the fine soil particles have much more total surface area than the large particles, and therefore hold more film moisture.

But tillage saves moisture for the plant in another way. Our

FIG. 38. — A leguminous cover-crop (clover) grown to improve an orchard soil. It protects the soil while growing, and when plowed in adds vegetable matter and nitrogen.
(p 90)

fathers cultivate their corn and cabbages and tomatoes, not only to keep weeds out, but also to keep the soil loose on top. Why do

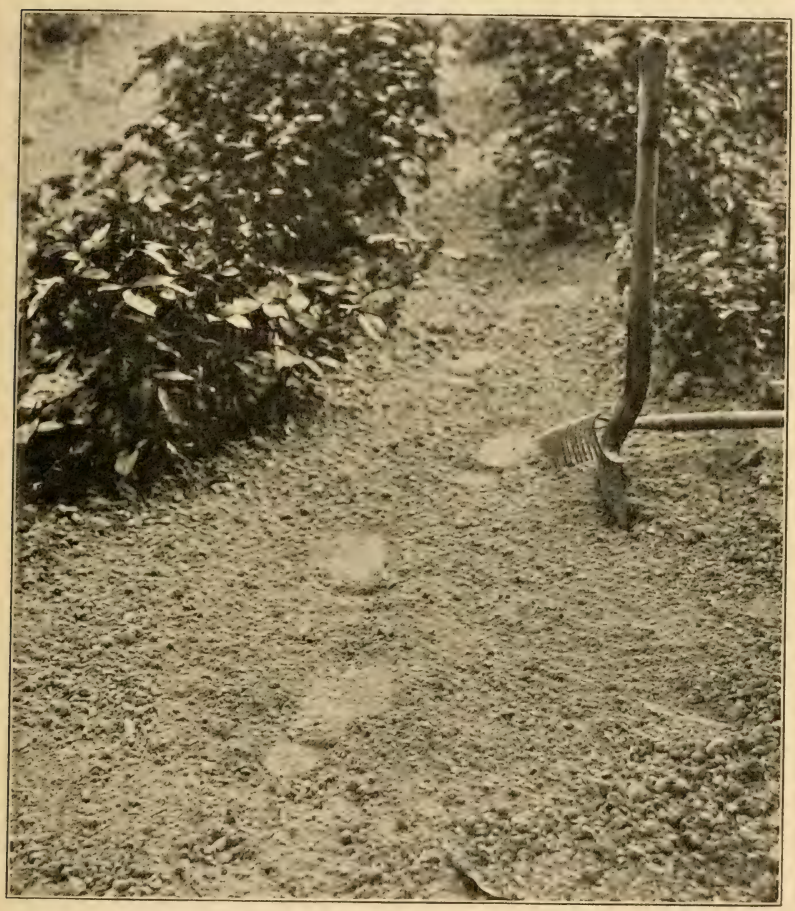

FIG. 39. — Good tillage saves moisture.

they keep two or three inches of loose soil on top, which dries out as soon as it is stirred, and that much moisture is lost?

Let us go out behind the barn or woodshed, and lift a board or large stone that has lain there throughout the spring and early

FIG. 40. — Tillage improves the orchard soil.

summer. We find that the soil is moist under it, while the ground about is dry. The stone has prevented the moisture from evaporating into the air. The loose layer of surface soil, which we call a mulch, acts in much the same way as the stone. It serves as a

FIG. 41. — Footprints compact the soil, and this brings the capillary water to the surface. That is why they are dark and moist.

blanket, covering all the field, to protect the lower layers of the soil from the strong summer heat and to prevent the moisture from escaping. By stirring and drying the surface mulch, its capillary moisture escapes. This breaks the connection with the chain of capillary moisture below and so this lower moisture is not lifted.

As soon as the soil becomes packed again by rolling, tramping, settling, or by its own weight, the chain becomes reëstablished and

FIG. 42. — A footprint showing how the soil is compacted.

moisture is again drawn up and lost into the air. To save moisture in dry weather the surface must be kept lightly tilled so that there will always be a loose, dry surface mulch.

The use of tillage tools. — The farmer needs many different kinds of tillage tools for different purposes. Some, as the plow, are to

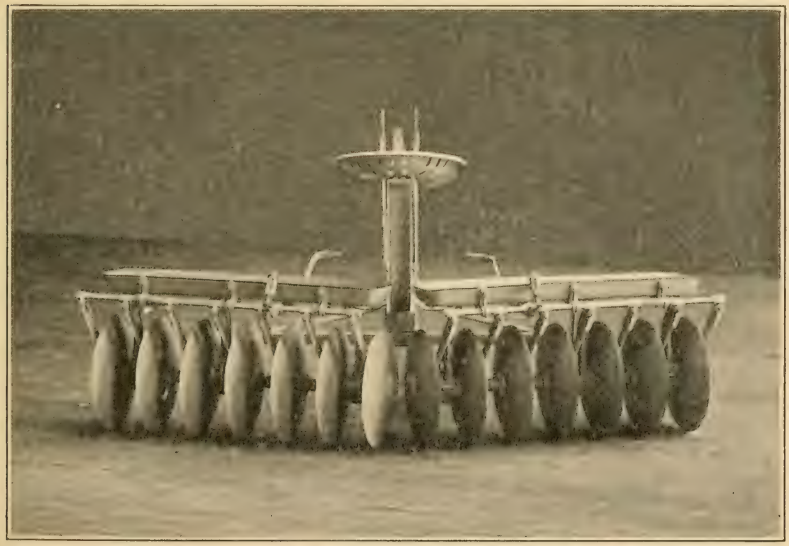

FIG. 43. — Disk harrow.

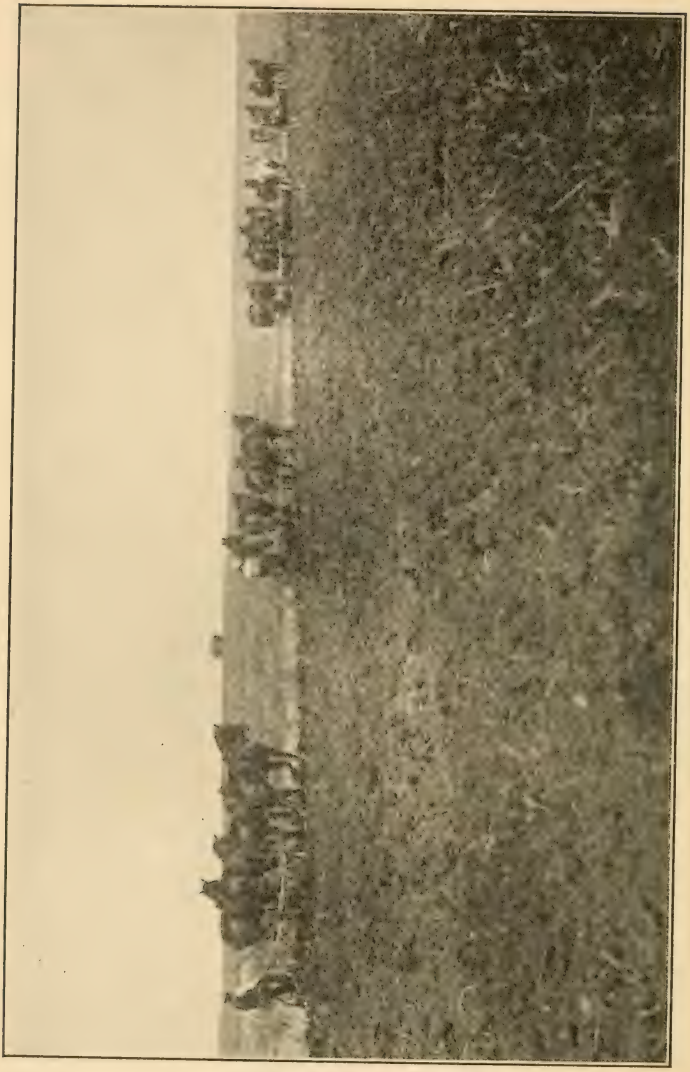

Fig. 44. — Plowing in the Northwest.

stir the soil deeply and to cover the sod or stubble that is on the surface of the ground. Others, as the cultivator, tear up the soil to less depth than the plow, and lift and turn it. Others, as the

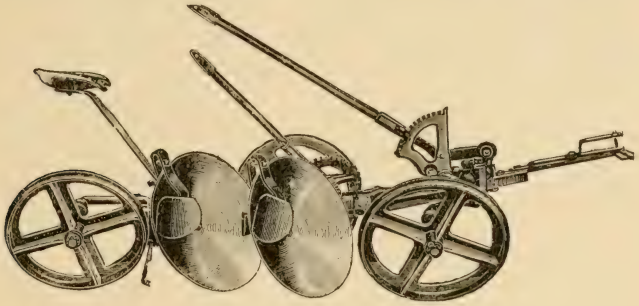

FIG. 45. — Disk plow.

harrow, prepare and pulverize the surface of the soil and make the soil mulch. Others, as the roller, compact the soil and are specially useful on light, loose, sandy, or gravelly soils.

There are many styles or types of each of these different tillage tools for special purposes. One kind of plow will not suit all conditions. There is a medium weight plow for the field and garden; there is a large, heavy plow for hard-packed or stony ground; another kind of plow to rip the sod on the plains; a hillside or reversible plow for sloping land or irrigated lands; a subsoil plow to reach deep and stir the lower soil. There are walking and riding plows and steam gang plows; and there are disk plows, which have

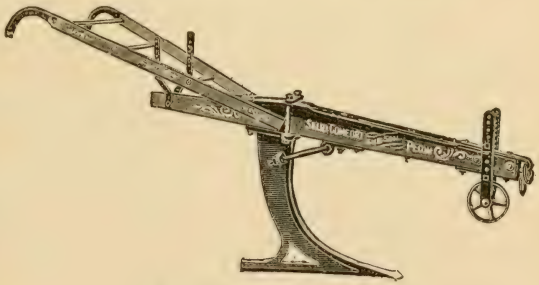

FIG. 46. — Subsoil plow.

circular, movable shares, for use in hard or sticky land. There are harrows with spike teeth or spring teeth or circular disk teeth, for different kinds of soil conditions. There are walking cultivators and riding cultivators, and they may have shovels or spring teeth or disks. There are cultivators to take one row, or two rows, or three rows.

Each tillage tool has its own use, and the careful farmer will choose his tools so as to get the ones that will do his various kinds of work best.

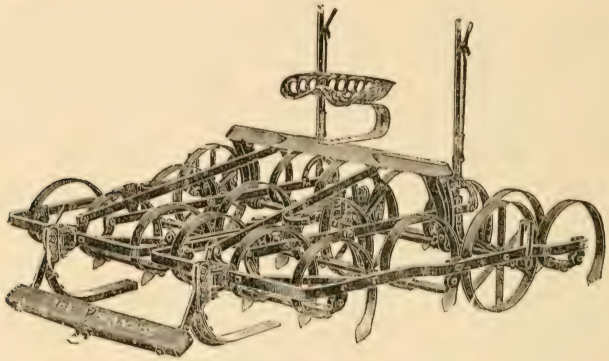

Fig. 47. — Spring tooth harrow.

Dry-farming. — We now hear much about dry-farming. It is a special kind of tillage, to save enough moisture so that crops may be grown every other year. The land is made deep and fine to catch and hold the rainfall; and then the surface is kept in good tilth to prevent the moisture from escaping.

The purpose is to store up enough moisture one year, when crops are not grown, to supplement the rainfall of the next year so that a crop can be grown during that year. The third year the land is bare again, to store up moisture for a crop to be grown during the fourth year.

Where the rainfall is normally 20 inches or less in the year, dry-farming or irrigation must be practiced.

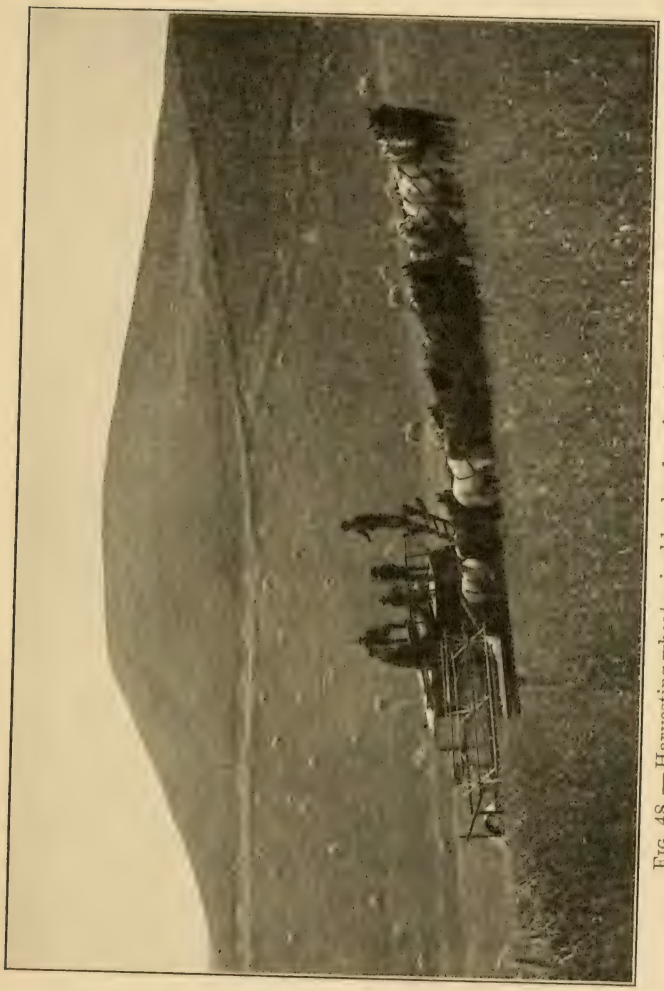

FIG. 48. — Harvesting wheat raised by dry-farming in the State of Washington.

Problem 70. Place some small marbles or pebbles in one tumbler. Put an equal weight of fine soil in another tumbler. We shall then have in the second tumbler the same amount of material as though the marbles or pebbles were ground into fine powder. Pour water into each tumbler until it stands on the top of the soil in one tumbler and just covers the pebbles in the other. Which takes the larger quantity of water? If we could measure the amount of film water, we should find that the soil has two to four times as much as the marbles. Tip the tumbers and let the water run out. Which loses the most water? Which holds the most? Why? What does this teach in regard to tillage?

Problem 71. Describe the different kinds of plows on your father's farm? What is each used for? Have you any old ones that are not used now? How are they different from the ones you are using?

Problem 72. Ask the teacher to write on the blackboard a list of all the different kinds of tillage tools, including those used by hand, on the farms in the neighborhood. The pupils should tell the teacher what to write. Then recite (or write) from this list what each is used for, how it stirs the soil, and when it is used.

Problem 73. Does your father plow in the fall or the spring? Why? Does he roll his land? Why? Why does he drag it?

Problem 74. For what crops on your farm must the soil be tilled in order that they may be planted? For what ones is it again stirred or turned in order to harvest them?

Problem 75. If you live in a dry-farming region, describe how the work is performed. If you live in a humid region, ask your parents or teacher to read you something about dry-farming. Where are the dry-farming regions?

Problem 76. What is the amount of the annual rainfall of your region?

CHAPTER XV

IMPROVEMENT OF THE SOIL

The first thing the farmer must do is to make his land productive; then he must aim to keep it productive.

Plant-food in the soil. — When studying the character and composition of the soil in Chapter X, we learned that plants take certain substances from it which we call plant-foods. These substances include elements called sodium, potassium, silicon, calcium, magnesium, phosphorus, iron, chlorine, and others. From the air the plant gets other elements called carbon, hydrogen, oxygen, and nitrogen.

A plant must have every one of these different plant-foods. Each contributes its part to the growth of the plant, and one cannot be substituted for another. If a soil contained all of them except potassium, it could not grow plants. If it contained enough of everything but phosphorus to produce thirty-five bushels of wheat, and contained enough phosphorus for only fifteen bushels of wheat, then fifteen bushels is all it could possibly produce. In order to be fertile it must contain a sufficient amount of each of the plant-foods to meet the needs of the crop to be grown.

Plant-food must be available. — Not every soil that contains an abundance of plant-food is fertile, however. Gravel-stones may contain all the necessary mineral plant-foods, and muck contains nitrogen; yet a mixture of gravel-stones and muck will not make a fertile soil. If the stones should be ground into soil, much available plant-food might result. In order to be available, or useful, the plant-food must be in such condition that it can be dissolved by the soil water; for plants can take their food only when it is dissolved in water, or is in liquid form.

Amount of plant-food in the soil. — The farm soil nearly always contains an abundance of the plant-food substances; but some of them may be present in very small quantities, or may be in such form that the plant cannot use them. Or the farmer may grow crops year after year and not return anything to the soil, and in this way greatly reduce the available plant-food. Of the fourteen substances, or elements, that make up the food of plants, only three, or occasionally four, are likely to be lacking. These are nitrogen, phosphoric acid, and potash, and sometimes lime.

When any one of these substances is lacking, it must be provided. Usually this is done in one of two ways: either by better tillage, which, as we know, helps to change plant-food into a form to be used by plants, or by adding the plant-food directly to the soil in the form of fertilizer.

There are two general classes of fertilizers: one, which is made on the farm, we call farm manure ; the other, which is generally bought on the market, is called by the farmer commercial fertilizer. Phosphoric acid, potash, and nitrogen may be added to the soil by the use of either of these kinds of fertilizers.

Phosphoric acid. — We have all seen phosphoric acid. When a match is struck, the little curl of white smoke which first appears is phosphoric acid. The old sulfur matches show this best. In the blue-black or red tip of one of these matches there is a small amount of the substance we call phosphorus. When this phosphorus is warmed by rubbing it against something, as in striking the match, it unites with oxygen from the air. The white substance of the smoke is the result of the union or combination of the phosphorus and the oxygen.

In a fertilizer purchased for its phosphorus, the phosphoric acid is united or combined with lime. The product is called phosphate of lime. Lime and phosphoric acid unite in three different proportions which have different values: 1 part of phosphoric acid with 3 parts of lime; 1 of phosphoric acid with 2 of lime; 1 of phosphoric acid with 1 of lime. It is

in the form of these three combinations that the plant gets its phosphoric acid. The first combination, 1 to 3, will not dissolve in water, so that it cannot be used immediately by plants. The second combination, 1 to 2, will dissolve in soil water because the soil water contains carbonic acid, which makes its action stronger. This form is therefore gradually made available to plants. The third combination, 1 to 1, will dissolve in water as readily as does sugar or salt, so that it is at once available to plants.

Phosphate is made chiefly from bones. In certain places in the southern part of the United States there are large bone deposits which are called "phosphate rock." In this rock the phosphate is in the 1 to 3 form and so will not dissolve in soil water. In order to make it dissolve, it is treated with a strong acid, called sulfuric acid, and water. The sulfuric acid takes some of the lime away, and reduces the combination to 1 to 2 or 1 to 1, which will dissolve in the soil water. The lime that is taken away unites with the sulfuric acid and forms a new substance called sulfate of lime. Gypsum, or land plaster, which the farmer uses for fertilizer, is the common name for this sulfate of lime.

Potash. — Potash, as well as phosphoric acid, must often be added to the soil. It exists in the soil, locked tight in a compound that will not dissolve in water; consequently, much of the potash is not available to plants. It may gradually be made available by tillage.

When vegetable matter decays, acids are formed which attack the locked-up potash and set some of it free for plant use. A soil that contains plenty of humus is likely to have potash in a usable form.

Potash can be bought as commercial fertilizer to apply to the soil. There are large deposits in Germany from which our supply comes. Wood ashes contain potash and are a good fertilizer.

Nitrogen. — Nitrogen in the form for plant use is found principally in the dark surface soil. It comes from the humus. There is

none of this element in common rocks. Four fifths of the air is nitrogen, and all nitrogen comes originally from the air.

In Chapter XIII we learned that plants can use nitrogen only when it is in the form which we call nitrate. When nitrogen is combined with oxygen, and with sodium, potassium, or lime, nitrates are formed. When organic matter decays in the soil, there results a form of nitrogen called *organic nitrogen.* This form is not of any use to plants. If the soil is well tilled and has plenty of of moisture, the bacteria will change the organic nitrogen to *nitric acid.* Then, by combining this form with sodium, potash, or lime, they will change it to nitrates. In this last condition it is ready to be used by plants.

Nitrogen may be added to the soil by plowing in vegetable matter, which we call green manure, or by applying barnyard manure; or it may be bought on the market in certain combinations of commercial fertilizer, such as sodium, nitrate, dried blood, and tankage. A very good way to add nitrogen is to grow legumes, or leguminous plants, which store nitrogen in their roots.

Animal manures. — Soils often need to be improved not only by the addition of certain plant-food substances, but in their texture as well. They may be infertile because of poor texture or because of lack of sufficient moisture. Barnyard manure is one of the best fertilizers to add to the soil because it not only supplies some nitrogen, phosphoric acid, and potash, but because it carries useful bacteria and contains much vegetable matter. The vegetable matter decays to form humus. This makes the soil lighter and warmer, and enables it to hold more moisture.

The manure from all farm animals is useful in improving the soil. Horse manure is richer in nitrogen, phosphoric acid, and potash than the manure from cattle or hogs. Sheep manure is very rich in these substances, and poultry manure is the richest of all.

Green manures. — All good farm soil must contain humus. The addition of vegetable matter to the soil is therefore an important step in the improvement of the soil. Sometimes the farmer will

grow a crop merely to plow into the soil to improve it. Such a crop is called a green manure, because the plants are generally plowed under when they are still green. The most useful plants for green manures are the legumes, as clover, alfalfa, peas, vetches, soybeans, and cowpeas, because they not only add vegetable matter to be changed into humus, but also add nitrogen. They are sometimes called nitrogen-gathering crops, because they gather nitrogen in the nodules on their roots. They are sometimes called cover-crops, because they cover or occupy the land when it otherwise would be bare, and catch-crops, because they are grown in the short intervals between the growing of other crops.

Storing an account for the future.—The soil is the farmer's bank account on which he must draw for his living for all the years to come. If he uses up his account, he will suffer. If he adds a little to his account from year to year, he will accumulate a good investment. If he robs his soil, takes plant-food out in the form of crops and puts nothing of equal value back in, he will reduce his soil fertility until he cannot raise crops. If he adds to his soil fertility from year to year, putting back what is needed, by good tillage, farm manures, green manures, or commercial fertilizers, he will store an account in the soil that will pay him well in big, well-grown crops.

When a farmer dies, or moves away, that does not end the usefulness of his farm. Some one else must make a living from it. A good farmer thinks of those who are to come after him. Some day all farmers will be of the kind that make the soil more useful rather than less useful by their farming.

On our farm. — It pays us to improve our soil. It is giving us a good living, and we must treat it so that it always will. On our garden we spread a good dressing of 5 to 10 loads per acre of rich stable manure in the spring and work it into the soil with a disk or spring-tooth harrow. If we need all the manure on the meadow, we apply one half to one ton per acre of a good commercial garden fertilizer to the garden. We have an orchard which we keep

tilled during the summer. In the late summer we plant a cover-crop or green-manure crop to protect the soil in the winter and to plow in the next spring.

We like to give our meadows a moderate dressing of manure, not only to help the grass, but because we expect to follow the grass by corn. Every three to six years we apply about 1000 pounds of lime on the fields where grass is grown in the rotation. On soils in some other parts of the country this may not be needed. When we plow under the sod, we add vegetable matter to the soil, and also receive benefit from the manure. When we plant the small grain after the corn, we sow in the grain-drill 200 to 400 pounds of a good commercial fertilizer containing nitrogen, phosphoric acid, and potash. We follow the grain with hay, and always plant clover in the hay, for it is valuable as cattle feed, and also enriches the soil. The plants that grow with the clover seem to be benefited by it also.

Problem 77. Does your father use barnyard manure on his farm for fertilizer? Where does he spread it? Why does he spread it there? Does he use commercial fertilizers with any of his crops? What does he use? Why does he use them with these particular crops?

Problem 78. Does your father grow any cover-crops to plow in? What kinds does he grow? Why? Does he sow them so that they will not interfere with other crops? When are they plowed in? Does he get good crops from the fields on which cover-crops have been grown?

Problem 79. Ask your father to explain to you all about his method of improving his soil. Write a short essay about soil improvement on your farm.

PART III

FARM PLANTS

CHAPTER XVI

THE NATURE OF PLANTS

PLANTS, like animals, must have food, water, and air. Also, they must have warmth and light. It is easy to see what animals eat and drink, but not so with plants. And yet, if we will, we may know in a general way how the plant gets its food and its air, how it digests and circulates its food, and how it grows and bears fruit. To understand these processes, we must know about the nature of plants, — what their different parts are and what they do.

Parts of the plant. — We know that a plant has three parts — roots, stem, and leaves. These perform for the plant three kinds of service; each has its own work to do. These parts work together in perfect harmony, just as do the parts of our own body; and together they form a living, growing plant.

The root system. — To study the root system we must have a plant before us to examine. Let us bring in from our gardens a radish, or a beet, or a turnip. We must dig it up carefully so as to save all the fine roots. Your radish will look somewhat like the one shown by the picture in Fig. 49. The upper

FIG. 49. — Radish, showing large, fleshy root, small tapering root, (*a*), and rootlet (*b*).

part of the root is large and round, and is stored full of food. Running out from the lower end of this large part is a common root about the size of a slate-pencil, which tapers to a point about five inches below. Fine rootlets are attached to the sides of it. Similar rootlets are attached also to the thickened upper part of the root.

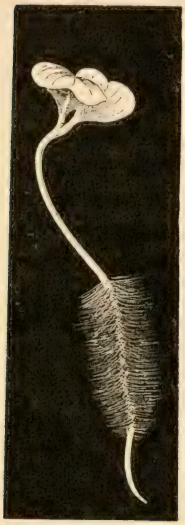

FIG. 50. — A very young radish plant, showing the root-hairs.

Root-hairs. — To understand how these rootlets obtain food from the soil, we must see the fine root-hairs that clothe them near the lower end. These hairs can be seen best if we germinate a few radish seeds so that no delicate parts of the roots will be injured. The root-hairs are very delicate, and we have broken most of them off in pulling the radish out of the soil. Sow a few seeds in packing-moss or between the folds of black cloth and keep them moist. In a few days the seeds will have germinated, and the roots will be an inch or two long. Lift one side of the cloth carefully and study the seedlings. Notice that at a distance of about one fourth inch from the tip, the root is covered with a delicate fringe of hairs. Dip one of the plants into water; when removed the hairs cannot be seen. The water has matted them against the root so that they are invisible. They are so delicate that it is no wonder we break them in pulling the radish from the soil.

These root-hairs clothe all the young, growing rootlets on the radish. But they are not young roots. They never grow larger. They differ from the remainder of the root. Each root-hair is a single cell, shaped like a tube, and contains the living matter of the plant.

The plant-food dissolved in the soil water passes through the walls of these root-hairs into the root system. There are no holes

or pores for it to enter, as we might suppose. It must pass directly through the walls, or surfaces, of the cells. It is able to do this because the cell contains sap, which is a stronger liquid than the soil water. The sap therefore draws or sucks the soil water through the walls. As the hairs are slender and very numerous, they are in contact with a large area of soil and consequently take in much soil water. The surfaces of the rootlets themselves also take in some soil water.

Fig. 51. — The root-hairs cling to the soil.

The root-hairs help to secure the plant-food in another way. They are provided with an acid, which, when it comes in contact with the soil particles, dissolves food elements that are needed. These are taken up by the soil water and so enter the plant.

Once inside, the soil water, containing its plant-food, passes into the rootlets, the roots, and up into the stem, by the same process by which it entered the root-hairs. It finally reaches the leaves, where, by the aid of sunshine, the water taken from the soil is united with the food taken from the air through the leaves, and starch, an important plant-food, is formed. The plant mixes, or combines, several substances to make its food, much as our mothers mix flour, milk, yeast, lard, and salt to make bread.

Perhaps we shall now understand why the roots cannot use solid soil particles. There is no place for solid particles to enter the fine root-hairs. It may be said that roots drink their food rather than eat it.

FIG. 52. — The years' growth. The large branches represent the ends of the different years growths of the main shoots. Maple.

The stem. — As the plant has a root system to gather the water and mineral foods needed in its growth, so it has a leaf system to take from the air the food substances which it needs from the air. The stem (or, in the case of trees, the trunk), branches, and twigs, connect the working centers, the roots and the leaves, so that they can exchange products needed by each other. In the stem are "ducts," or tube-like channels, in which the soil water travels upward rapidly to the leaves. There are other channels, made by a chain of cells, through which the food manufactured in the leaves is carried to the roots and to the other parts of the plant, to be stored or to be used in growth. The stem supports the leaves, and is an important link in the circulatory system of the plant.

The leaf system. — Air is a gas; that is, it is a substance that is

neither a liquid nor a solid. The food that plants take from the air is said to be in gaseous form. We are interested in the substances the plant takes from the air, how it gets them, and what it does with them.

Carbon. — A considerable part of every plant is made up of a substance called carbon. At least half of the bulk of a tree, aside from the water it contains, is carbon. When a piece of wood, as the limb of a tree, is charred, the black charcoal that remains is carbon. A corn plant in the roasting-ear stage is about four fifths, or 80 per cent, water. After the water has been taken out, only about one fifth, or 20 per cent, of the plant remains. The part that remains after the water has been evaporated is called the "dry matter" of the plant. It is the solid part. Carbon, and the substances or elements with which it is united, make up more than nine tenths of the dry matter of the corn plant.

The plant gets its carbon from the air. Strange as it may seem, much of the solid part of the plant comes from the air in the form of gas. If we burn the corn plant, nine tenths of the solid matter will pass back again into the air in the form of a gas which we call "carbon dioxid." This is exactly the form in which the carbon was taken from the air. This gas is composed of one part carbon to two parts oxygen, both being gases. If we represent carbon by the letter C, and oxygen by the letter O, we could represent carbon dioxid by CO_2.

How the air enters the leaf. — The leaf is delicate in texture and often the air can enter directly into it through its walls. However, nature has provided special openings, called stomates or stomata, for the entrance of air into the plant. These stomates are small pores, which are very numerous on the under side of the leaf. They are so small that they cannot be seen by the naked eye. The under side of an apple leaf has about 100,000 pores to each square inch. The air passes into the leaf through the pores.

Leaf-green or chlorophyll. — The substance which gives plants their green color is called "leaf-green" or "chlorophyll." It exists

as small oval bodies, or chlorophyll grains. These grains are specially numerous on the upper side of the leaf, where they are exposed to the sunlight. That is why the upper side is generally a darker green than the lower side.

The leaf-green is produced only in plants or parts of plant exposed to the light. It has been determined that light and leaf-green together are the means by which the plant is able to take its carbon from the air. Plants containing no chlorophyll can form no starch, because they contain no carbon. During the hours of sunlight, the plant takes in carbon dioxid by means of the chlorophyll grains.

The leaf-green absorbs the energy of the sun's rays, which it uses in uniting the carbon dioxid obtained from the air with some of the water brought from the soil by the roots. The product is called starch. It is composed of carbon, hydrogen, and oxygen. Water is composed of hydrogen and oxygen. There is more oxygen than is needed when the water and the carbon dioxid unite, and it is returned to the air. Starch is made only in leaves that are exposed to sunlight. No starch can be formed in the dark.

Starch is formed in very small grains, which will not dissolve in water. It is therefore not in a form for immediate use by the plant in growth, and must first be "digested." It is digested by a substance called a ferment which acts on the starch and changes it to sugar; and we know that sugar readily dissolves in water. In this latter form it is circulated to all parts of the plant where growth is taking place. In woody plants, as trees, it flows downward through the inner bark, just under the surface. In spring the maple sap is sweet, because it contains this dissolved sugar on its way to supply the needs of the roots.

Not all of the starch is needed for immediate use by the plant, and so the surplus is stored for use in the early spring. The fleshy part of our radish contains stored-up starch. Fruit-trees usually blossom in the spring before they are able to make any plant-food that season. The young leaves and the blossoms must then be

supported by the food that has been stored in the branches, twigs, and buds during the previous season.

Protoplasm. — What has become of the mineral foods carried into the plant and up to the leaves in the soil water? In the leaves the soil water meets the liquid containing the substances which have been taken in from the air. These two liquids unite, and there is formed a product called protoplasm. Protoplasm is the real living matter in plants. It contains sulfur, phosphorus, potassium, and other elements. It exists in the plant cells, where it stimulates all the activities of the plant.

FIG. 53. — The effect of transpiration. The slip on the left has lost its moisture by transpiration, and has wilted. On the right, the upper tumbler has prevented much of the transpiration, and the slip is still fresh.

Transpiration. — In Chapter XI we learned that crops take from the soil 300 to 500 tons of water to make one ton of dry plant substance. Some of this water is used in the plants in dissolving and circulating the foods, and in keeping the plants "fresh," and strong. But much more water is taken into the plant than is needed. The surplus is given off from the leaves into the atmosphere by evaporation. This process is known as "transpiration"; that is, the leaves transpire or give off moisture. If the leaves give off more moisture than the roots supply, the plant wilts. The water is then taken out of the cells, out of the circulatory system, and the cells collapse. This teaches us again the necessity of an abundance of moisture in the soil.

The flower and the fruit. — When roots, stem, and leaves have stored a sufficient surplus of food, the plant begins to flower. The flower springs from a bud on the stem or on a twig. Sometimes the flower is prominent and beautiful to look at, as on the apple tree, and sometimes it is not so readily distinguished, as in wheat or oats.

Very much has been intrusted to the flower. It contains the organs, or parts, which create the fruit. The fruit contains the seeds, from which new plants are to be grown. The flower is therefore the reproductive part of the plant. If it fails to do its part, there will be no fruit and no new plant, unless a new plant can be started from a slip or cutting from the old plant. The first work of the fruit is to nourish and protect the young seeds in their development. The flesh of the apple is not made by the plant merely to be eaten by the boy, but to nourish and protect its seeds while they are forming.

Parts of the flower. — If you were to open a flower of the peach, you would find the very small peach in the center. This part is called the "pistil." In the apple flower, the pistil has five parts or branches. Around the pistil in the peach and the apple blossom are the "stamens," that bear the "pollen." When the pollen falls on the pistil, it causes the pistil to set seed and fruit. Bees and the wind carry the pollen. Peach and apple flowers are inclosed in showy leaves or parts called "petals."

Problem 80. Dissolve one ounce of saltpetre, purchased at a drug store, in one pint of water. Mark it Solution I. Dissolve a small piece of saltpetre, not larger than a peach pit (about one seventh ounce), in one gallon of water. Mark the latter Solution II. Cut several slices of potato tuber about one eighth of an inch in thickness and let them lie in the air for a half hour. Then put a few of the slices into some of Solution I and others into some of Solution II. In about one half hour compare the slices in the two solutions. The pieces in the weak solution (No. II) will be rigid and stiff. Those in the strong solution (No. I) will be limp and flexible. This indicates that those in the strong solution have lost some water from their cells, while those in the weak solution have taken some water into their cells.

This experiment illustrates the way in which water is taken into the roots. As long as the soil solution is weaker than the living matter in the root, water is taken into the roots. When the soil solution becomes stronger than the root solution, the moisture from the root is drawn into the soil. The passage is always toward the stronger solution. It is possible to make soils so rich that plants cannot grow. The root-hairs can absorb only water which contains but a small amount of plant-food.

Problem 81. Remove a small plant from the ground carefully, by lifting it out with a shovel, spade, or trowel. Then slowly wash away the earth till all the roots or rootlets are exposed. Note how extensive the roots are, the size and shape, the mode of branching. See whether you can find any difference between the roots of oats and wheat.

Problem 82. To show that the root-hairs excrete an acid that dissolves minerals, place a half inch of sawdust on a polished marble block. Plant seeds in the sawdust and moisten it. After the small plants have produced a few leaves, turn the mass of sawdust over and observe the prints of the roots on the marble. The lines on the marble show where the mineral has been dissolved.

Problem 83. Can a farmer apply too much fertilizer to his soil? Why?

Problem 84. What plants grown on your father's farm store up starch for future use? Where is it stored?

Problem 85. When potatoes sprout in a dark cellar, why are the sprouts white instead of green? How can they sprout, without being planted in the ground?

Problem 86. Find the pistils and stamens in some flower that you know.

CHAPTER XVII

CLASSIFICATION OF PLANTS

THERE are many different kinds of plants in any locality. A five-minute walk through the fields or the woods will reveal a great variety to a wide-awake, observing boy or girl. There are trees of many kinds, shapes, and sizes; some are open and wide-spreading, others are dense and compact; some are evergreen, others are bare in the winter; some bear fruits, some nuts, some cones. There are erect, sturdy bushes and low, sprawling bushes. There are vines that creep on the ground, others that creep over rocks, others that climb trees. There are delicate flowering plants, and mushrooms and toadstools. In the soil are countless hosts of microscopic plants; in the water, sea-weeds and other water plants; in the marshes, sedges, lilies, and cat-tails.

The farm plants. — On the farm there is also great variety among cultivated plants. There are tree fruits and bush fruits; slender, upright grasses, and low, trailing clovers; thick, heavy root crops, and light, waving grains; loose, leafy lettuce and solid, round cabbages. Some plants live for many years, others for but one year; some produce many bushels of fruit, others a single fruit; some lift their fruit in the air, some bear it on the surface of the ground, and some hide it in the soil. Some grow in thick, tangled masses, others grow alone. Each has a habit of life of its own, and will grow where it can live its own life best.

Why there are differences. — Plants have become adapted to all places on the earth where life is possible. The great variety of conditions in nature has called for many kinds of plants. Some

locations are wet, others dry; some are sunny, others shaded; some are exposed to the wind and the storm, others are secluded, quiet, and protected; some are rocky slopes, others are deep,

FIG. 54. — Young tobacco plants growing under a lath shade.

fertile valleys; some are sandy, others stiff clay. In the many centuries of the past, certain kinds of plants have been gradually adapted to meet each of these various conditions, and the result is shown in the variety we have to-day.

There is yet another reason why all plants are not alike. Most plants produce large quantities of seeds. It is not possible for nearly all of these seeds to grow, because of lack of space on the surface of the earth. This results in a struggle for place, a struggle that never ceases. When certain plants win the chief places, others must adapt themselves to what is left. Thus, in the meadow there are tall grasses, lower-growing clovers, and below them still smaller grasses and weeds. In the fence row are bushes, grasses, weeds, and trailing vines. The competition develops variety. Plants are plastic; that is, they may change to meet the conditions in which they must live.

The farmer has taken advantage of this plastic or variable nature of plants and has modified the cultivated plants to suit his wishes. He has thus added to the diversity in plant life. The many varieties of tomatoes in our gardens to-day are very different from the wild tomato from which they have been developed. The wild apple has little use; yet from it man has created an almost endless number of useful varieties.

How plants are classified. — These differences in form, habits, length of life, and other qualities have been taken advantage of in grouping or classifying plants for purposes of study and comparison.

We may classify plants according to their length of life; we then have a group of annual plants, which live not more than one year from the planting of seed to the production of new seed, as wheat, oats, barley, peas, beans, and tomatoes; a group of biennial plants, which live two years from seed to seed, as beets, parsnips, and common mullein; a group of perennial plants, which live more than two years, as asparagus, alfalfa, sweet clover, strawberries, bushes, and trees.

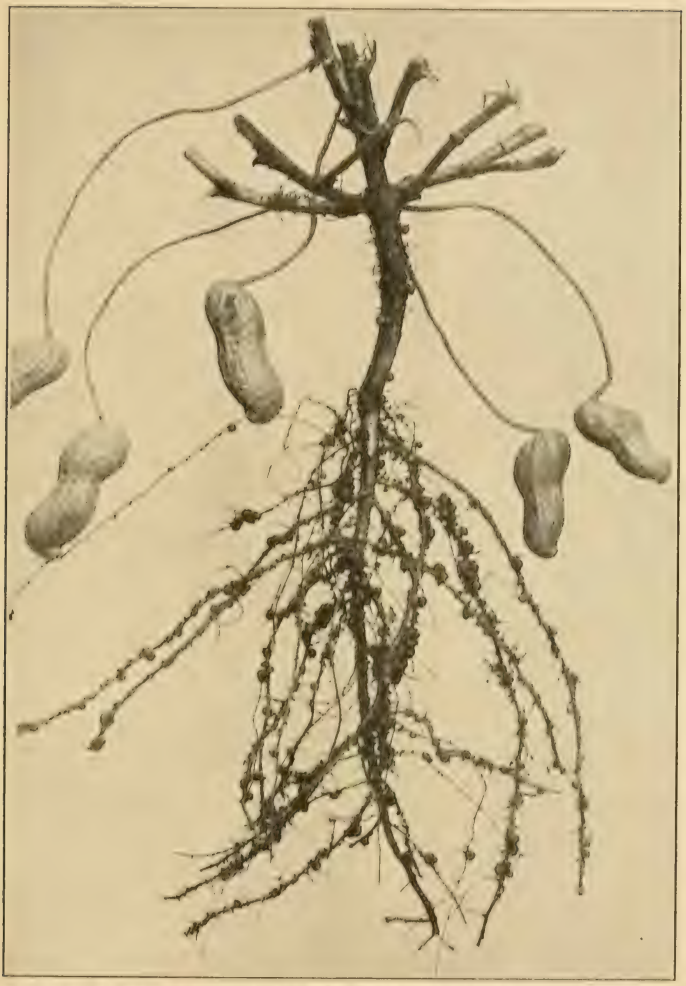

FIG. 55. — Part of a peanut plant, showing roots, root nodules, and nuts. The nuts are borne underground.

Use. — Another very common classification of plants, based on the use that is made of them, together with their habits of growth, is as follows: —

(1) Forage and fodder crops, as timothy, alfalfa, sorghum, and corn fodder.

(2) Cereal crops, as wheat, oats, rye, barley, and rice.

Fig. 56. — A cotton plant bearing a large crop.

(3) Root crops, as carrot, parsnip, turnip, mangel, beet, and sugar-beet.

(4) Fiber crops, as flax, hemp, and cotton.

(5) Fruit crops, as apple, peach, pear, quince, currant, and blackberry.

(6) Vegetable crops, as tomato, pea, bean, cucumber, and celery.

(7) Ornamental plants, as rose, lilac, geranium, sweet pea, and nasturtium.

(8) Timber crops, as oak, chestnut, maple, and pine.

There are other special groups that might be added, as sugar plants, oil plants, perfumery plants, spice plants, dye-stuff plants, and medicinal plants.

Fig. 57. — Oats.

When we speak of forage crops, or root crops, or cereal crops, the person to whom we are talking knows at once what kind of plants we are speaking about, because these groups are well established. And as nearly all the plants in each group have certain characteristics in common, especially in their cultivation, such a grouping is useful in describing them.

The botanist's classification. — The farmer is satisfied to classify his plants as forage crops, root crops, vegetable crops, and the like. These general groups are sufficient for his discussions. Some of these classes, however, include plants of very unlike characteristics and habits, and sometimes it is desirable to group

plants according to similarity of characters.

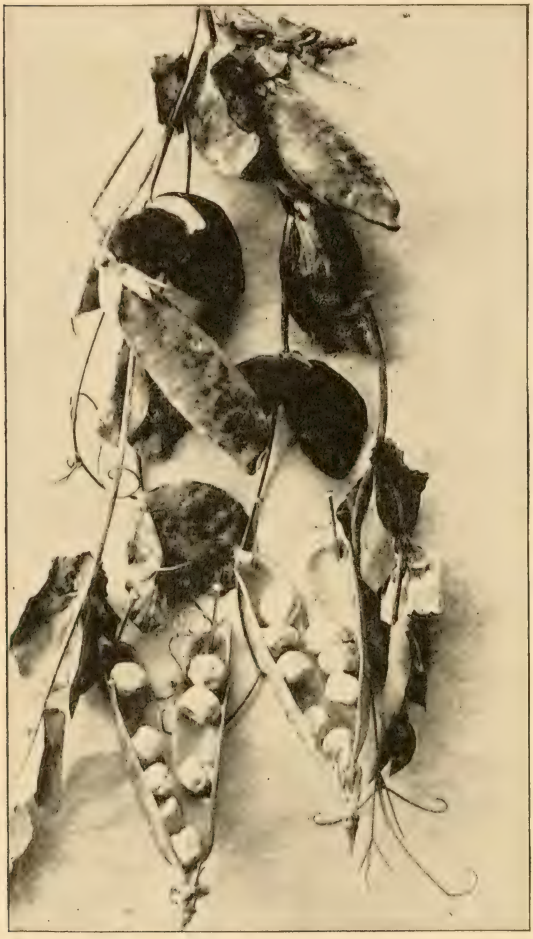

FIG. 58. — Pea. "Leguminous" plants bear their seeds in a certain kind of pod called a "legume." Peas, beans, clover, alfalfa, cowpeas, and vetch are examples.

The botanist, the person who makes a very close study of plants to find the important resemblances among them, groups them into families. He places in a plant family all those plants that seem to be related in their general nature. He gives these families Latin names. Thus, in the grass family (Latin name, *Gramineæ*) he places timothy, blue-grass, orchard-grass, red-top, wheat, oats, rye, barley, corn, sugar-cane, and others. In the rose family (*Rosaceæ*) he places apples, peaches, plums, raspberries, blackberries, strawberries, and others. In the pulse family (*Legu-*

minosæ), peas, beans, clovers, vetches, and alfalfa. In the mustard family (*Cruciferæ*), mustard, cabbage, kale, rape, turnip, rutabagas, and radishes. In the nightshade family (*Solanaceæ*), potatoes, tomatoes, egg-plants, peppers, and tobacco. There are many other plants in all of these families, some of which are not of importance to the farmer. And there are many other plant families besides these.

It is of interest to know in what plant family each of our farm plants belongs, and what other plants are its relatives. Perhaps we should learn, first, whether a plant is a fruit, vegetable, root, cereal, or forage plant; then whether it is an annual, biennial, or perennial; and finally, to what family it belongs.

Problem 87. How many different kinds of plants are grown in your garden? Which produce underground the part that is to be eaten? Which produce their product on the surface of the ground? Which are vines?

Problem 88. Do you think that the squash, the pumpkin, the cucumber, and the muskmelon belong to the same family? Why?

Problem 89. What resemblance is there between the potato and the tomato? Do the plants look alike in any respect? Are the leaves similar? The flowers?

Problem 90. Name some of the annual plants on your father's farm; the biennial; the perennial.

Problem 91. Write a list of all the plants on your father's farm that belong in each of the following groups: forage and fodder crops, cereal or grain crops, fruit crops, vegetable crops, and root crops.

CHAPTER XVIII

DISSEMINATION AND MULTIPLICATION OF PLANTS

Long before man came to live on the earth, plants had established themselves on its surface. They grew, produced other plants, and perished. They did not need the interference of man to plant their seeds or their roots, or to carry them from one place to another. Nature provided them with all the means of multiplying and spreading that were needed.

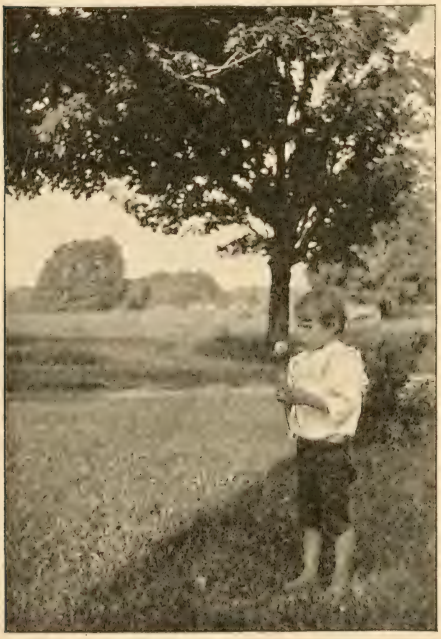

Fig. 59. — One of the ways in which seeds are scattered.

Nature's method of distributing plants. — Some of the plants, as the cocoanut, were encased in snug, water-proof jackets, so that they could float on the surface of streams to new regions. Others, as the maple seeds, were given wings to carry them on the wind. The dandelions were provided with parachutes so light that man could never have kept them from sailing away in the breeze if

he had tried his best. The burdock and stick-tight were given little coiled arms to clutch the fur of a passing animal and ride away to a new home.

The tumble weed excelled all others in cleverness. In the autumn, when its seeds were ripe, it broke off at the surface of the ground, and by the wind was swept tumbling across the field, leaving a trail of seed wherever it passed. The wild carrot, not to be outdone, sent its seeds skiddering across the country on the smooth snow in winter. The touch-me-not provided itself with a spring which, when the ripened pod burst, threw the seeds far away from the parent.

Fig. 60. — Millet's seed-sower.

Other plants were given bright, attractive seeds, that tasted good to birds, which ate them and scattered the seeds in their flight. Still other plants simply walked away from their parents and took up new homes for themselves. The white clover and the strawberry reached out their branches as far as they could from the parent plant, sent down roots, began to make their own living as independent plants, and separated from their parents. The blue-grass reached out in the same way underground, and sent up, all about the parent, new plants which soon became independent.

With so many means of multiplying, it is little wonder that the earth is covered with a great variety and tangle of plants, all struggling for place and opportunity to live.

Man's method. — When man began to live a settled life, he discovered that he could not depend on Nature to plant his garden, for

she had a way of mixing and tangling her plants greatly. He desired to choose his crops, plant them in rows instead of tangles, and control them to suit himself. So he collected seeds and roots, carried them to the place where he wanted them to grow, and planted them.

The means of multiplying plants which he used varied with the different kinds of plants. Some were multiplied, or propagated, most readily by the use of seeds, others by the use of roots or other parts. The farmer to-day propagates his plants mainly by the use of seeds, roots, tubers, cuttings, buds, and grafts. He has found that he must employ many methods to get the best results from different kinds of plants.

Propagation by seeds. — A seed is a body produced by a plant, which contains a very tiny undeveloped plant called an "embryo."

FIG. 61. — Squash seed.

The embryo is surrounded by food, stored for its use when it shall begin to grow. The purpose or use of the seed is to produce a new plant like the one from which it came. When placed in the right conditions of moisture, temperature, plant-food, and air, the seed will sprout and a plant be produced.

Nearly all farm crops are grown from seeds, especially those that are annuals. Wheat, oats, barley, beans, peas, corn, lettuce, rad-

ishes, and beets are always raised from seeds. This is the simplest method of multiplying plants, as seeds are usually produced in great numbers, are easily collected and stored, and may be planted with little difficulty. They may be sown broadcast by walking across the field, or may be dropped into holes or trenches; and they may be planted by machines or by hand.

Propagation by other means. — Some plants, as sweet potatoes and sugar-cane, seldom produce seed; others, as grapes and strawberries, grow faster and better by the use of other parts than seeds; in still others, as apples and potatoes, the seed cannot be depended upon to produce a new plant similar to the parent, and the farmer cannot be sure what he will get if he plants seed. In all of these cases he finds it better to use parts, or sections, of the parent plant for starting his new crop. The part that he uses is not the same for all plants, for some plants reproduce better from one part than from another. We shall study how these different parts are used.

FIG. 62. — The potato is a storehouse of food. When it is set in water, shoots grow out from its eyes, or buds.

Roots. — The sweet potato is a good example of a plant in which the root is used for starting the new crop. The edible part of the sweet potato is the root. When this is planted, it throws up many sprouts that have roots of their own. When these sprouts are pulled and planted, they will produce other sweet potato plants.

Tubers. — A tuber is a greatly enlarged part of a plant, particularly of the stem that is grown underground. Usually we think

that the stem of a plant is all above ground. In the case of the white, or Irish, potato, part of the stem is below ground. This part grows large and forms what we call the potato. The potato, then, is not really a root, as we may have thought, but is a stem. We call it a tuber. The potato plant has other true roots.

The most familiar farm crop that is multiplied by the use of tubers is the potato. These tubers may be planted whole, but usually it is more economical to cut them and plant pieces having about two eyes. These eyes are buds from which new plants spring.

Cuttings. — A cutting is a part of a plant, cut from the parent, which is used to produce a new plant. Some plants grow much better from cuttings than from seeds. Most house-plants and many woody plants raised on the farm are started from cuttings, or slips.

Cuttings may be made from the stem, from a branch or twig, or from a leaf. In starting new grape vines, a short section having three buds is cut from the growth of the preceding season. Two of the buds are placed below ground for the formation of roots, leaving one above ground for the growth of the new vine. With sugar-cane, the short sections of the stalk carrying one or more buds are laid horizontally in the soil and lightly covered with earth. Currants and willows are readily started from cuttings. All of these form roots from the cut stems and become perfect plants.

Buds and grafts. — There are other plants that are not usually multiplied by the use of seeds, and which do not readily develop roots from the stem. In some way they must be established on the roots of other plants. This is accomplished by transferring a bud from the plant it is desired to increase to the stem of another plant, and inserting it below the bark. Here it will attach itself and begin growth as part of the new plant.

Sometimes, instead of using a single bud, the farmer will take short sections of a branch bearing more than one bud. Such a section is called a graft, or *scion*. It is attached to the plant

of which it is to be a part by cutting off the stem or branch of the latter and inserting the scion in the cut end.

Buds and grafts always produce the same kind of tree or plant as that from which they were taken. Apples, peaches, plums, pears, and cherries are nearly always grown from buds or grafts. They grow on the roots of other plants, and not on roots grown by themselves. The budding or grafting is usually done in the nursery row while the plant which is to supply the roots, called the *stock*, is very small and only one to three years old.

Problem 92. If there is a fruit-grower in your neighborhood, ask him to show you how to bud and to graft. Watch him cut the bud and the scion, and ask him questions.

Problem 93. In winter or spring, cut a section having three buds from last year's growth of the grape vine. Place it in a pot of moist sand with two buds below ground. When the young plant has well started, take it out of the pot and see where the roots came from. Set it out near the fence in your school yard to grow.

Problem 94. If there is a strawberry bed on your father's farm, find a plant that has reached out and started another plant. Bring it to school.

Problem 95. Write a list of fifteen plants on your farm or in the neighborhood, and tell how they are multiplied.

Problem 96. How is the common garden geranium multiplied? The fuchsia? The onion?

Problem 97. Dig up a potato plant and find the real roots.

CHAPTER XIX

ROTATION OF CROPS

On every farm several different kinds of crops are grown. When the farmer has a definite plan by which he moves his crops from one field to another from year to year, so that one crop always follows a certain other crop, we say he is rotating his crops, or is practicing crop rotation; that is, he is growing his crops in a circle or rotation, one after another, returning to the same field with a certain crop every four or five or six years. If he is merely growing different kinds without reference to a real system or plan, he is practicing what is called diversification.

What crop rotation is. — Suppose a man has a dairy farm and is raising his own hay, corn, and small grain. Let us say that each year he raises the same number of acres of corn and small grain, and twice as many acres of hay. He desires to rotate his crops, so he divides his farm into four fields of equal size. We may call his fields *A*, *B*, *C*, and *D*. He has decided that he will plant corn on land that produced grass the last two years, follow the corn with small grain, sow grass seed in the grain, then let the grass grow for two years before he plows it for corn. How will he rotate his crops on his fields? Let us study the following chart and see: —

	Field *A*	Field *B*	Field *C*	Field *D*
1912	Corn	Hay	Hay	Grain
1913	Grain	Corn	Hay	Hay
1914	Hay	Grain	Corn	Hay
1915	Hay	Hay	Grain	Corn
1916	Corn	Hay	Hay	Grain
1917	Grain	Corn	Hay	Hay

On Field *A*, in 1912, he will plant corn; on Field *B*, hay; Field *C*, hay; Field *D*, grain. That gives him equal areas of corn and grain and twice as much hay. In 1913, he follows corn with grain on Field *A*, plants his corn on Field *B* which last year raised hay. He leaves Field *C* in hay for the second year and follows grain on Field *D* with hay. In 1914, he moves his crops all forward to the next field, following grain with hay on Field *A*, following corn with grain on Field *B*, plowing sod for corn on Field *C*, and allowing the hay to remain for the second year on Field *D*. In 1915, the crops move forward again. In 1916, the beginning of the fifth year, his rotation has reached its starting point, and each crop has returned to the field on which it was grown in 1912.

It takes four years to complete this rotation. It is a four-year or four-course rotation. The fifth year it begins a new round. It is a definite plan, or system, which gives the farmer each year just what he wants without growing the same crop on the same field oftener than once in four years, except in the case of hay, which is left purposely for two years.

Each year half the hay land is plowed. If the grass seed is sown with the small grain, it will not grow enough to interfere with the grain. It takes possession of the ground after the grain has been harvested. It will therefore not be necessary to plow the grain land after the harvest to plant the grass; and as only one hay field is plowed each year, the farmer will plow half of his farm each year instead of all of it. This makes less work.

This is a simple rotation, which is in common use. Other rotations may be planned for more fields, more crops, or for a greater or less number of years. The farmer may work out nearly anything he desires. But he should always have a regular plan, or system.

Why crops are rotated. — In experiments at Rothansted, England, wheat was grown on the same land for sixty-two years in succession. At the end of that time the yield per acre was only one fourth as much as for wheat grown on similar land for fifty-

two years as part of a four-year rotation. The rotation was responsible for the great difference in yield.

Let us see what benefit will come from using the four-year corn, small grain, and hay rotation given on page 130. Corn is tilled or cultivated between the rows when it is growing. This loosens the soil, helps to improve the texture, and by admitting air aids in making plant-food available. It also destroys weeds. When the grain is sown it occupies all of the land closely and helps to choke out many weeds. It uses the plant-food in the soil in different proportions from the corn and helps to even up the demand. When grass is planted, clover is sown with the timothy. Clover is a leguminous plant, and therefore, as we have learned, makes the soil richer. The hay crop uses the plant-foods in still different proportions, so that the demand is further evened up. Then when the sod is plowed under it adds a great deal of vegetable matter to the soil to be made into humus. Stirring the soil for the corn which follows helps to decay this vegetable matter.

We learned in Chapter XV the many benefits that come from plowing vegetable matter into the soil. If corn only, or wheat only, were grown, there would be very little vegetable matter added, and the soil would suffer from need of it.

Chess and cockle are weeds that grow with wheat and become very destructive when land is constantly in wheat. They are destroyed by the grass crop followed by clean or constant tillage such as is given for the corn.

When one crop is grown constantly on the same field, it seems to injure the soil in some way. This injury is avoided when crops are regularly changed. Furthermore, some plants have short roots and take all of their plant-food from near the surface of the soil, while others have long roots that reach deep into the soil in search of food and moisture. Wheat, radishes, and onions are short-rooted and take their food from the first six inches of soil. Alfalfa may send its roots as far down as thirty feet.

Planning a rotation system. — The farmer will choose a rotation

that meets the particular needs on his farm, His next door neighbor may have a very different rotation. If he is raising stock, his rotation will be planned to include the crops needed for feeding. If he is a grain-farmer, and desires to grow as much grain as possible, he will have a different rotation. If the soil is poor, the rotation will include the frequent use of leguminous crops and the plowing under of green-manures to improve it. If the farm has sandy soil, a different system must be planned from that used for clay soil. One rotation is useful in a cool, moist climate, another in a hot, dry climate.

In all of these cases, the farmer will plan his rotation so that each crop will leave the land in the best condition for the one that is to follow. Wheat and rye leave the land in good, smooth condition for hay, and consequently hay often follows wheat or rye in the rotation.

The farmer will also plan his rotation so that his farm help will be used to the best advantage throughout the year. He will plan to distribute his planting and his harvesting so that it will not all come at one time and be more than his men can do.

When all of these conditions have been carefully considered, the farmer will try to plan a rotation that will include a " money crop," that is, one that will go directly to market; a clean-tilled crop, or one that is tilled between the rows during the growing season; a hay or straw crop; a leguminous or soil-improving crop. Such a rotation will keep the land rich and will not allow weeds to grow. In the rotation on page 130, the small grain may be the " money crop," the corn is the clean-tilled crop, and clover, in the hay, is the leguminous crop. The hay and corn, and perhaps some of the small grain, will be fed on the farm.

If the farmer is raising a special crop, as a gardener near a large city is likely to do, and cannot practice crop rotation to any extent, he must buy considerable fertilizer and stable manure to keep his land in good condition.

History of crop rotation. — When settlers come into a new

country and find the land rich, they are not likely to rotate their crops with any special care. As long as the land is fertile, they are not concerned as to how they shall keep it so. As soon as one piece becomes poor from unwise farming it is deserted and another piece taken up to be ruined in the same way. It is only when all the land becomes poor that they begin to think of the importance of a careful system of farming.

This is just what took place in America. George Washington, who was a thoughtful farmer as well as a great statesman, became alarmed at the carelessness of the farmers about him in his day. He saw that they were robbing their land of fertility by their lack of careful system. In 1787, he wrote the following letter to his friend Arthur Young in England: —

"Before I undertake to give the information you request, respecting the arrangements of farms in this neighbourhood, &c, I must observe that there is, perhaps, scarcely any part of America, where farming has been less attended to than in this State (Virginia). The cultivation of tobacco has been almost the sole object with men of landed property, and consequently a regular course of crops have never been in view. The general custom has been, first to raise a crop of Indian corn (maize), which, according to the mode of cultivation, is a good preparation for wheat; then a crop of wheat; after which the ground is respited (except from weeds, and every trash that can contribute to its foulness) for about eighteen months; and so on, alternately, without any dressing, till the land is exhausted; when it is turned out, without being sown with grass-seeds, or reeds, or any method taken to restore it; and another piece is ruined in the same manner. No more cattle is raised than can be supported by lowland meadows, swamps, &c., and the tops and blades of Indian corn; as very few persons have attended to sowing grasses, and connecting cattle with their crops. The Indian corn is the chief support of the labourers and horses. Our lands, as I mentioned in my first letter to you, were originally very good; but use, and abuse, have made them quite otherwise.

" The above is the mode of cultivation which has been generally pursued here, but the system of husbandry which has been found so beneficial in England, and which must be greatly promoted by your valuable Annals, is now gaining ground. There are several (among which I may class myself), who are endeavouring to get into your regular and systematic course of cropping, as fast as the nature of the business will admit; so that I hope in the course of a few years, we shall make a more respectable figure as farmers than we have hitherto done."

In Washington's time the land was " respited," or rested, or allowed to remain idle after it had been injured by careless farming. To-day the best farmers do not " rest " land to improve it; they practice crop rotation, good tillage, and the use of fertilizers and manures, and keep the land in good condition.

Crop rotation has become a regular practice on farms all over this country, and hundreds of different rotations are in use. Americans are becoming better farmers.

Problem 98. Do all the farmers in your neighborhood raise large crops? If one raises specially large crops, ask him to tell how he does it, what fertilizers he uses, and what is his rotation of crops.

Problem 99. Explain what kind of rotation is used on your father's farm, and why it is used. Which is the money crop? Which is the clean-tilled crop? Which is the leguminous crop? Are all of the fields included in the rotation? If not, are the crops as good on those not in the rotation?

Problem 100. How often are the meadows plowed on your farm? What is planted after the meadow? Why? Do the farmers that keep their land in hay for two or three years get larger crops than those who keep it in hay for five or six years? At haying time, compare a field that is in hay for the second year with one which has been in hay for several years. Decide whether it pays to rotate the hay crop.

Problem 101. If your father does not rotate his crops, see whether you can plan a rotation for him. Write out a rotation, explaining why you place the crops in certain order. Ask your teacher to tell you whether it is a good rotation.

Problem 102. Suppose a farmer raises potatoes, rye, and hay to sell. What should be his rotation? Why?

CHAPTER XX

INDIAN CORN

As far back as we can go in the history of man, we find that he depended on corn for much of his food supply. In many places in the Bible we read about the cornfields. In the book of Genesis it is said that "Joseph gathered corn as the sand of the sea, very much, until he left numbering; for it was without number." Many centuries later it is written that Jesus and His disciples passed "through the cornfields."

Maize. — But this was not the same kind of corn that is called by that name in America to-day, and which was not known until after the discovery of America. The name "corn" has been given to several different grains by different peoples in various parts of the world. In the book of Ruth we read that Ruth asked "to go to the field and glean ears of corn . . . so she gleaned in the field until even, and beat out what she had gleaned; and it was about an ephah (a little more than a bushel) of barley." In the northern part of Europe, corn is the name given to rye; in England, corn means wheat; in Scotland, a field of corn is understood to be a field of oats. Thus we see that the name corn is applied to all of the grains. The original meaning of corn was a grain or hard seed, and all of these plants have been called corn just as we now call them all grains.

We speak of these grains also as cereal grains, or cereals. The word *cereal* comes from Ceres, the name of the goddess of agriculture, worshipped by the Romans over two thousand years ago. Ceres watched especially over the grains.

The corn of America originated in southern Mexico and was extensively grown there centuries before the discovery of America. As the Romans brought to Ceres the first fruits of their grain harvest, so the native Nahuas of old Mexico sacrificed the first fruits of their cornfields to Centoatl, their goddess of maize, or corn. Long before Columbus landed in America, the plant had spread into the temperate regions of both North and South America. When Columbus reached the West Indies, he was given by the natives a bread made from a grain called mahiz. He used this name in his letters to Spain, and from it has come our word *maize*, commonly applied to corn. In a letter to Ferdinand and Isabella, dated May 30, 1498, speaking of his brother, Columbus says, " During a journey in the interior he found a dense population entirely agricultural, and at one place passed through eighteen miles of cornfields."

In 1519, Cortez, on his march to the city of Mexico, passed " amid flourishing fields of maize." In 1539, De Soto, in Florida, speaks of Indian villages surrounded by extensive fields of corn. In 1680, La Salle found stores of corn in Illinois that the Indians had placed underground for seed and food supply.

Place of maize in American agriculture. — The cultivation of corn, Indian corn as it was called, was the chief dependence of the early colonists as it had been of the Indians before them. It was already well established and grew luxuriantly. The settlers learned from the Indians how to prepare the corn for food. Roger Williams, in speaking of the forms in which corn was used for food in New England, says, " Samp (from the Indian name for the dish, *nasaump*) is the Indian corne, beaten and boiled, and eaten hot or cold with milke or butter, which are mercies beyond the native's plaine water, and is a dish exceeding wholesome for English bodies."

From colonial days to the present, corn has held an important place in American agriculture. To-day it is the most important American crop. It can be grown in nearly every part of the continent. It has become adapted to all the various climates from

Canada to the tropics. For the short seasons of the north there are varieties that ripen in 70 or 80 days and grow but three or four feet tall. In southern United States, Mexico, Central America, and South America, there are varieties that grow to a height of twenty feet or more and require six months in which to complete their growth. Corn fits well into crop rotation systems, and this has led to its being grown in regions where a few years ago it was not an important crop.

The corn or maize plant. — Let us go out into a field of standing corn, or bring a corn plant into the schoolroom and study it. We should know that the worst foe of the corn plant is wind, and it has been obliged to develop certain forms of stalk, leaf, and root to enable it to withstand this foe. If we cut a corn stalk across, we find that it is a strong cylinder with a pithy center. It is strengthened at short intervals by hard nodes, or joints. If all of the stalk were as compact and rigid as the nodes, it would break in the wind instead of bending. As it is, the stalk is elastic, and will bend far over without breaking. The nodes are near together at the bottom, thus giving strength to the base; they are farther apart at the top, where the wind strikes and where the stalk must bow rather than break.

The corn leaf comes from the stalk at a node. Its base clasps the stalk completely for some distance, thus making the latter stronger. Just where the leaf bends away from the stem is a small growth, which fits tightly around the stalk and is called the rain-guard because it prevents rain from seeping down between the stalk and the clasping leaf, where dampness would harbor destructive fungi.

The structure of the corn leaf is especially adapted to escape injury from the wind. The strong veins are parallel and there is a flexible but strong midrib at the center. The most severe wind storm injures only the tips of the leaves. The edges of the leaf are ruffled; this allows a sidewise movement without breaking the margins.

The true roots of the corn plant, which begin their development from the planted seed, penetrate the soil rather deeply, but they are

hardly able to hold firm a stalk so slender and tall as that of the corn plant when the wind blows fiercely against it. Hence, all about the base of the stalk are certain roots, which we call brace-roots, the office of which is to hold the stalk erect.

Blossoms. — Each fertile cornstalk has two kinds of blossoms. Those that bear the pollen appear at the tip of the stalk; we call them corn "tassels." The other flowers are those that develop the seed and are the pistillate flowers, which we call the ears of corn. They consist of many small white ovules set on a central stalk or cob. Each ovule has a long style, which we call the corn silk. Very delicately are these pistillate flowers of the corn wrapped about with leaves, which are changed to the soft protective clothing called the "husks." Each white ovule thrusts its thread of silk upward until its tip pushes out beyond thetop of the husks, and each silk is tipped with a stigma, which is ready to receive the pollen that falls upon it from the tassels of its own stalk or is blown upon it from the tassels of other corn plants.

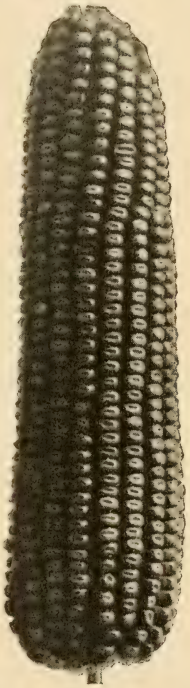

FIG. 63.—A well-shaped ear of yellow dent corn.

If one of these ovules fails to receive pollen at the tip of its long, silken style, it does not develop into a kernel of corn, and the ear will then be imperfect. Such undeveloped kernels we say are "blasted." These ovules are set upon the stem or "cob" in twin rows; thus each row is double, being made up of pairs of ovules. If the different varieties of corn are planted one near another, the pollen from one kind may be carried by the wind over to the ears of the other kinds, and the result will be a mixture of two or more varieties on the same cob.

Ears. — The ears are borne at the joints or nodes; and where the ear presses against it, the stalk is grooved to hold it more snugly. The husks show plainly that they are modified leaves, in the following ways: The husk has the same structure as the leaf; the outside husks are green and, therefore, do the work of leaves. The husk often changes to leaf-shape at the tip of the ear, thus showing that the husk itself is that part of the leaf which normally clasps the stalk. As a matter of fact, the ear of corn is on a branch

FIG. 64. — The husks often change to leaf-shapes, showing that they are modified leaves.

stalk, which has been much shortened so that the nodes are very close together, and the leaves, therefore, come off close together.

By stripping the husks back, one by one, from the outside stiff green leaf structure to the inner stalk, the papery wrapping for the seed may be seen in all its stages.

Kinds of corn. — There are eight distinct kinds, or "species," of corn. They differ from one another in certain important characteristics. They are, first, a wild form, sometimes found in Mexico; second, pod corn, in which each kernel is inclosed in a

Fig. 65. — Corn.

separate pod or husk; third, popcorn; fourth, flint corn, a hard smooth corn, generally yellow in color, grown in New England and other northern states; fifth, dent corn, which has a dent or depression in the large end, is yellow or white in color, and is grown

in both the north and the south; sixth, soft corn, not grown in North America; seventh, sweet corn, having a horny and more or less crinkled appearance, used for table purposes; eighth, starchy sweet corn. There are many varieties of most of these classes, so that there are wide differences in the types of corn grown in different places.

The culture of corn. — The seed for planting should be chosen the fall before from the standing corn, for it is important that the seed come from thrifty stalks that yield the largest amount of corn. The ears should be of good length, strong, and well filled at tip and butt. A few kernels from each ear of the seed corn should be tested to be sure it will sprout vigorously. We shall learn how to test seed in Chapter XXXI.

The soil should be the most fertile on the farm. Sod land which grew clover the preceding year, and which received a dressing of barnyard manure during the winter or early spring, is ideal. It should be plowed early, and harrowed repeatedly until the seed-bed is fine and smooth.

Planting should be delayed until the weather is warm all day long. If it is to be done by hand, furrows should be made across the field, generally in its longest direction, about three and one half feet apart. The corn will be planted in hills, three kernels in a hill. In the East, where corn is thinned after the plants are up, as many as five seeds to the hill may be planted. For large varieties the hills should be three and one half feet apart in the row, and for small varieties a shorter distance. The seed is covered with fine soil one or one and a half inches deep. If a horse-drawn corn planter is used, it will not be necessary to make the furrows.

A few days after planting, the weeder should be run over the field to stir the surface and destroy the sprouting weeds. About a week after the corn shoots can be plainly seen in the rows, the first cultivation should be given. This should be fairly deep. The later ones may be less deep. Frequent cultivation benefits corn, and four or more cultivations should be given during the

growing season. The surface should be left fine and nearly level. The hoe must be used to keep the weeds out of the rows.

FIG. 66. — Cutting corn with a harvester that has an attachment to carry the stalks until a bundle is formed.

Harvesting. — Harvest time is at hand when the lower leaves on the stalks begin to die and many of the husks are becoming dry. The stalks may be cut by hand or with a corn harvester. About sixty hills may be gathered into one shock and the tops bound together to make the shock stand. If the corn is heavy, smaller shocks should be made. If they are too large, the corn on the inside will not cure well. If the weather is good, the corn will be cured in six weeks.

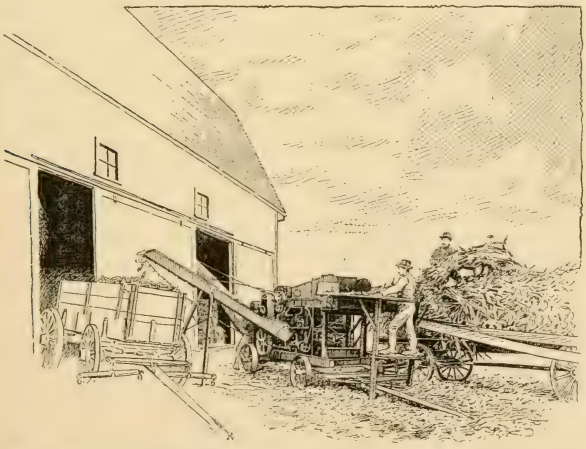

FIG. 67. — A machine for husking and shredding corn at work.

After the ears have been husked,

the stalks should again be bound together and stored under cover for winter use. If the fodder is to be fed to stock, it should not be left in the field during the late fall and winter. If the fodder is not to be fed, it is better to leave the ears on the stalks until the latter are thoroughly dry. The ears, after husking, should be stored where air can circulate about them, and where they will be free from rats and mice.

The silo. — The silo is a receptacle in which green forage plants are stored in quantity in such a way that they will remain green and juicy, or suculent, and wholesome. It is much used on stock farms to preserve green corn, clover, alfalfa, and other forage plants, so that in winter the cattle may have fresh food. Corn is the principal crop preserved in this way.

The first silo in Europe was a stack of wet grass covered with earth. In America, the first ones were pits in the earth. Most of these in use to-day are wood or cement structures built above ground and adjoining or part of the cattle stables. They are usually built in the shape of a cylinder, but may occasionally be square.

When the corn is grown for the silo, it is not planted in hills, but the seed is sown so as to have a stalk about every seven inches in each row, the rows being three and one half feet apart. It is harvested for the silo when the lower leaves are turning yellow, and when the kernels begin to be hard and no milk comes out of them when they are mashed.

Enemies. — Crows and blackbirds are the enemies of the young corn plant. They must be frightened away from the field until the corn is too large for them to pull it up. Cutworms lurk about the hills and cut off the stalks. Coating the kernels of seed corn with coal tar before planting will drive away some of the enemies after it has been placed in the ground.

Uses. — Although corn is produced in America much more extensively than other grains, very little is exported. It is nearly all used on the farms where it is produced to fatten cattle and hogs for market.

Aside from the use of the fodder, grain, and meal for feeding, there are many other corn products of commercial value. The silks are used in the making of filters; the husks for the making of mattresses; the pith for the packing of coffer-dams of battleships; the outer parts of the stalk for the making of varnish and for paper; the cobs for corn-cob pipes. An oil used in the arts is extracted from the seed germs. Starch and alcohol are made from corn. There are many other products that might be mentioned. One factory makes forty-two different corn products.

Problem 103. Do the roots of the corn plant penetrate deep into the soil? Why? Describe the brace-roots. How do they help the plant to stand firm against the force of the wind? How far up the stem do the brace-roots come off?

Problem 104. Where on the stalk are the ears borne? How many ears on a stalk? After removing the husks carefully note whether there is a thread of corn silk for every kernel. How many rows of kernels are there on the ear? Are there always an even number of rows?

Problem 105. How many varieties of corn are grown in your locality? What is each kind grown for? Are all of the varieties planted in the same way? Describe the differences. Is it the most important crop in your region?

Problem 106. For what is the corn raised on your father's farm used? Is any of it shipped away? Where does it go? What becomes of it?

Problem 107. Who grows the best corn in the locality? How does he fit his land? What crop precedes corn in his rotation? How does he secure his seed? How often does he cultivate the growing crop?

CHAPTER XXI

WHEAT

WHEAT has held a leading place in the food supply of all the greatest nations of the world since the beginning of history. It has been grown so long and in so many different countries that there is difficulty in determining where it originated. Monuments much more ancient than the Hebrew Scriptures show that it was an important plant at the time they were built. The earliest Lake Dwellers in western Switzerland cultivated a small-grained variety of wheat. The ancient Egyptians and Greeks believed that it had been originated by some of their deities, among them Demeter (Latin, Ceres), the goddess of agriculture. It was grown by the Chinese at least 2700 years B.C., and was considered by them a direct gift from Heaven.

Western Asia, especially the valley of the Euphrates, is supposed to have been the original home of this plant. A wild grass native to the Mediterranean region at the present time bears a resemblance to the wheat plant.

Wheat in America. — It is believed that wheat was not known in America before its discovery by Columbus. Within two weeks after the arrival of the first colonists at Jamestown, in 1607, this crop was sown on land that had been cleared by felling timber for the fort. In the year following, additional land was cleared and planted. The first attempts were not especially successful, but the colonists persisted and from year to year planted wheat in increasing quantities. The crop was harvested with the reap hook and the sickle and was trodden out by horses and oxen instead of being threshed with a flail.

As early as 1626 wheat was cultivated by the Dutch in New York.

It held a leading place in the middle colonies and was among the very few crops exported. The Pennsylvania millers gained a wide reputation for the excellence of their flour.

Wheat was sown at Plymouth in 1621. It did not become an important crop in New England during colonial times. In 1838, great efforts were made to encourage the growing of it, and that year the Massachusetts legislature offered a bounty on wheat, which was paid to 3642 farmers on 108,570 bushels.

Production. — Wheat is now grown in nearly all civilized countries. Vast areas are planted in Russia, India, France, Austria-Hungary, Argentina, Canada, and the United States. Europe produces more wheat than any other continent, raising nearly twice as much as North and South America together. In 1909, the total product for the world was estimated as 3,624,418,000 bushels, of which 911,933,000 bushels were grown in North America.

Wheat-growing has followed the westward movement of population in the United States. In 1850, New York was one of the leading wheat-producing states. At that time, the four states which now produce the most wheat were, with the exception of Ohio, still unsettled. Now New York raises very little wheat. Ohio, southern Wisconsin and northern Illinois, Minnesota, North Dakota, and Kansas have each, in turn, led in the production of this crop. Western Canada has recently become a great wheat-growing region.

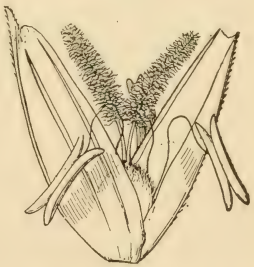

Fig. 68.—The wheat flower, showing two stigmas and two of its three anthers.

The wheat plant. — Let us bring a few wheat plants to school or, better still, go out to a field of ripening wheat, and study the habits of this plant. We shall find that, unlike the corn stalk, the wheat stalk is hollow, although occasionally it may contain more or less pith. We may wonder how the hollow stem is able to support the heavy head as it is swayed in the wind. It is because a hollow

tube is very much stronger than a solid cylinder made from the same amount of material. The nodes, which are solid joints, support the sides of the tube and keep it from collapsing.

Fig. 69. — A head, a spikelet, and a grain of a bearded wheat.

We see that the nodes are nearer together at the base. This is because there is greater strain here. The walls of the stem become thicker toward the base for the same reason. Wheat grows rapidly because each section of the stem, between the nodes, lengthens at the same time; and the stem elongates at the tip, also, so that there is growth throughout its entire length at one time.

When the seed germinates, it throws out three temporary roots which gather moisture for the young plant. As the stalk grows nodes are formed close together on it. Additional roots spring from each node. The permanent roots are formed near the surface of the ground. They branch outward and downward and may sometimes reach a depth of four feet or more.

If wheat is planted in the fall, the stalks do not rise above the crown of leaves produced at the surface of the ground until after winter is past. The leaves, or blades, that cover the winter wheat-field like a mat, are snugly protecting the roots from the cold.

The head or " spike " gradually develops as the plant grows tall. It is the flowering part, and the place where the fruit or grain is to be produced. When it ripens, the leaves at the surface of the ground, together with those at each node, wither and fall, and the whole plant turns a golden yellow color.

A habit of importance to the farmer is the tendency of the wheat plant to tiller or stool; that is, to throw up additional stalks from the same seed. From twenty to as many as one hundred stalks may spring from one seed. Each stalk develops its own roots, so that it is soon independent of those with which it is associated. Seed that tillers heavily will, therefore, make the growth in the field much more dense; it will give a heavy " stand " of wheat.

Kinds of wheat. — The different kinds of wheat in America may be divided into classes according to where they are grown and whether they produce hard or soft grains. Thus we have: —

(1) The soft winter wheat, grown chiefly in New England and the middle states.

(2) The semi-hard winter wheat, grown in the north central states.

(3) Hard winter wheat, grown in parts of the middle plains states.

(4) Soft spring wheat, grown on the Pacific coast.

(5) Hard spring wheat, grown in the upper Mississippi River basin.

(6) The durum or macaroni wheat, grown in the Great Plains states.

Often we call them all either winter wheat or spring wheat, meaning by winter wheat that which is sown in the fall and is in the ground over winter, and by spring wheat that which is sown in the spring and harvested in the fall.

Culture. — Wheat will grow on a great variety of soils, but seems to do best on a light clay. The land that is to be used for winter wheat should be plowed as early in the preceding season

as possible so that it may be made fine and be able to absorb moisture during the summer. The land that is to be used for spring wheat should be plowed the fall preceding or early in the spring. In either case the surface must be made fine and loose to receive the small seeds.

If wheat follows corn in the rotation, the land should receive ten to thirty loads of barnyard manure before it is plowed for the wheat. A fertilizer containing nitrogen, phosphoric acid, and potash is valuable, and may be applied after the land has been prepared.

Wheat should never be grown on the same land year after year, or the soil will become too poor to grow good crops. It should always be grown in a rotation. It commonly follows corn, oats, or potatoes.

The winter wheat should be planted early enough in the fall for the young plants to make sufficient growth to be able to withstand the cold of winter. The spring wheat may be planted early, as wheat seed will germinate and grow in cool temperatures.

The grower should be very careful to choose good seed. Six to eight pecks should be sown to the acre, and the seed should be planted one to three inches deep, depending on the condition of the soil. The lighter and looser the soil the greater the depth. Wheat is not ordinarily cultivated after the seed has been planted.

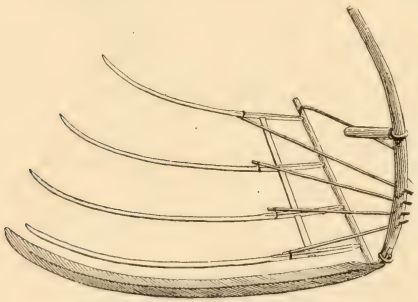

Fig. 70. — The grain cradle.

Harvesting. — The wheat harvest extends over five months. It begins in May in Texas, moves gradually northward through the summer months, and may continue as late as September or October in North Dakota and Washington.

For centuries, wheat was harvested with the sickle and the cradle, and these tools are still used in some countries. To harvest the great American wheat crop, machines have been devised to do all of the work on a large scale. It is scarcely necessary for the

Fig. 71. — The old way of harvesting grain crops, still occasionally in use on small areas.

hand to touch the grain in the entire harvesting process. The self-binder is used extensively. It cuts and binds the wheat into bundles. On some of the large grain farms in the western part of the United States there are as many as fifty self-binding harvesters, and as much as six hundred acres of grain are cut in a single day.

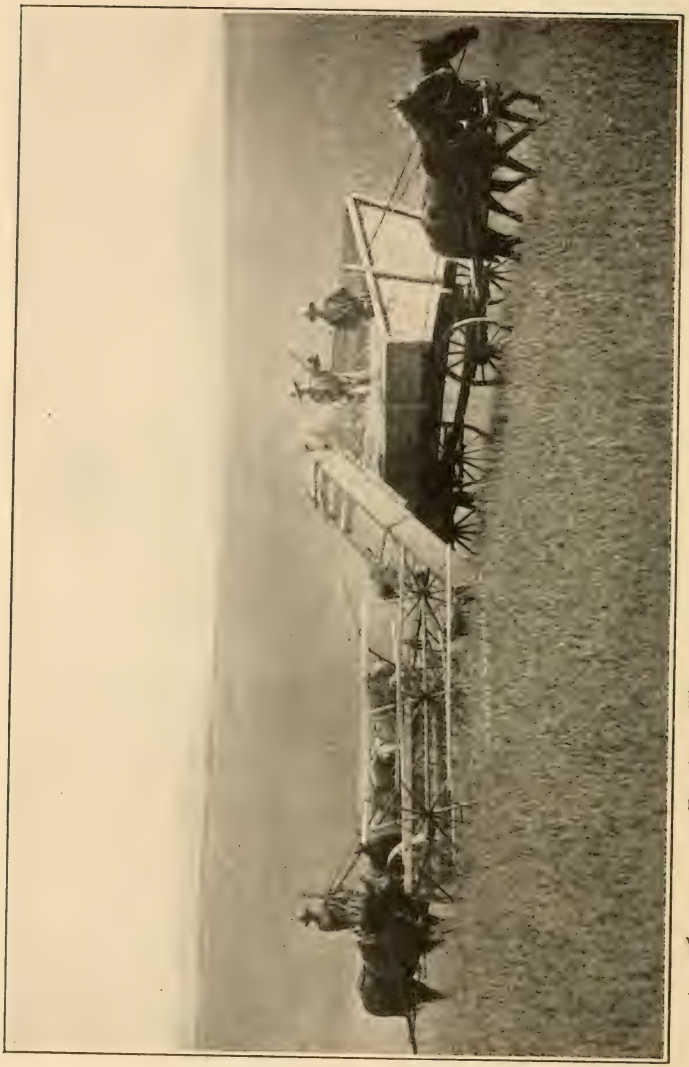

FIG. 72. — The new way of harvesting wheat on large areas.

The greatest labor-saving machine is the combined harvester and thresher used in the Pacific coast states. It is drawn by 20 to 30 horses, or a steam traction engine, and will cut 60 to 100 acres of wheat in a day. This machine cuts the wheat, threshes, cleans, and bags the grain, and carries the sacks until it has enough to make a pile before they are dumped.

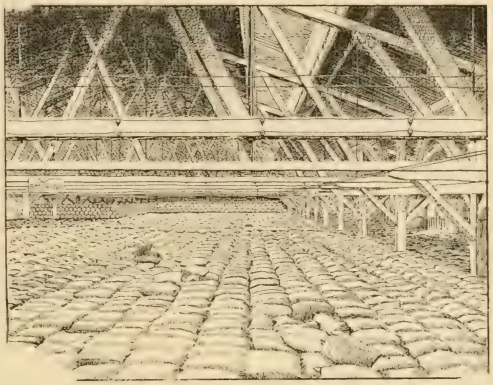

FIG. 73. — View of the interior of a grain warehouse on the Pacific coast, showing the grain in bags.

Uses. — Most of the wheat grown in America is made into flour for bread-making or is used in the manufacture of breakfast foods. The grain, either whole or ground, is a stock food. Wheat

FIG. 74. — One of the famous wheat growing sections in Idaho.

bran and wheat middlings, other common cattle foods, are obtained from the manufacture of flour. Macaroni is made from durum wheat. Starch made from the wheat kernel is much used as a material for paste or sizing.

The straw is used for feeding or for bedding cattle. When traction engines are employed to harvest the crop, the straw is burned to make the steam. Wheat straw is also used to make fine straw hats and bonnets.

Problem 108. How important is the culture of wheat in your locality? Why?

Problem 109. How many acres of wheat are grown on your father's farm? What is the largest acreage on a farm in your locality? What is the average yield per acre? Do you know what the average yield per acre is for the United States? Do the farmers in your locality help to raise or lower the average?

Problem 110. What does wheat follow in the rotation on the farms in your locality? What follows wheat? Is the rotation a good one? Why?

Problem 111. What is done with the wheat raised in your locality? If it is shipped away, what becomes of it?

Problem 112. Make a list of the kinds of foods used on our tables that are made from wheat or its products.

Problem 113. Compare a wheat plant and a corn plant, and explain in what ways they are similar. Is there any similarity in the roots? In the stems? In the way the leaves clasp the stems? In the arrangements of the nodes on the stem? In the shape of the leaves? In the flower parts?

Problem 114. Write a short essay, telling how wheat is grown in your locality: when it is planted, how the soil is prepared, how it is fertilized, how the seed is sown, how the crop is harvested, and what becomes of it.

Problem 115. How many kinds of wheat do you know? How do you tell them apart?

Problem 116. Can you tell the difference in May between a field of oats, wheat, and rye? How?

Problem 117. In what ways is wheat used on the farm? What is done with the straw?

CHAPTER XXII

GRASSES — MEADOWS AND PASTURES

In the story of the Creation we read that God commanded the earth to " bring forth grass." Grasses have covered the face of the earth since the time that vegetation became possible. Before tillage began, grasses occupied the land.

FIG. 75. — A field of rice before the water has been drawn off.

Grasses are of almost endless variety, and are grown from the hottest tropical regions to the frozen north and south. They vary in size from delicate moss-like plants less than an inch high to the gigantic bamboos 100 feet or more in height. They are adapted

to all sorts of conditions: dry, infertile soils, rich, moist soils, marshes, stagnant pools, slow-running streams, rocky hillsides, or sandy sea-shores.

Native grasses. — Every country has great areas of native or unsown grasses, which occupy unbroken or wild land. Perhaps you can find small areas of " volunteer " or unsown grass-land in your own locality. The native grasses are of great importance, for they not only supply pasture and forage in many cases, but also

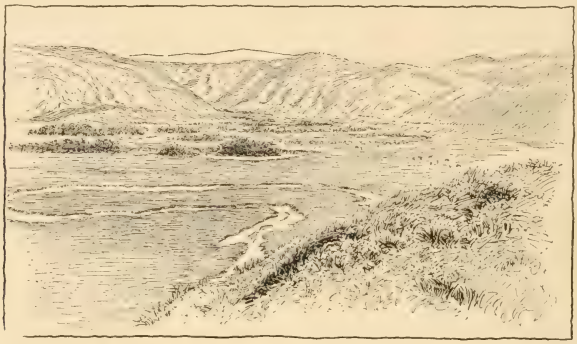

FIG. 76. — A stretch of native, or wild, pasture land in Nevada.

keep the land from washing and blowing. While a large part of the native grasses are not useful to the farmer, yet many of them are, as we shall see.

In the Great Plains region there still remain immense tracts of open prairie from which are cut large quantities of native hay. In the Rocky Mountain states millions of cattle, sheep, and horses live on the native grasses. It is said that 300,000 to 500,000 sheep alone pass the winter on the Red Desert of Wyoming.

In the Great Basin, extending from Oregon and Idaho to northern Arizona and westward to the Sierra Nevada Mountains, the stock roam in the hills during the summer, and in the autumn are turned into the meadows after the native hay has been stacked.

On the Pacific slope are other extensive native feeding grounds bearing hundreds of varieties of wild grasses.

Cultivated grasses. — Throughout most of America farmers cannot depend largely on native grasses. They must grow greater quantities to the acre, and must include the grass-land in their rotation systems. Also, they desire to choose varieties that will be most valuable to them. We have therefore a long list of cultivated grasses which are adapted to various climates and soils. Some of

FIG. 77. — Drawing hay on solid-wheel wagon.

them are most useful in meadows for cutting as hay, and others in pastures for grazing.

Many of the hay plants are not true grasses, but are legumes. Clover, alfalfa, and cowpeas are legumes. They are used for hay and forage, just as are the real grasses, but they are not true grasses. They belong to a different family of plants.

In northeastern United States, extending as far south as Virginia and westward to Kansas and North Dakota, timothy and red clover furnish most of the hay, and Kentucky blue-grass (also called June-grass) a large part of the pasture.

Farther south, in the cotton-belt, the most important hay plant is cowpeas, which is a legume. Bermuda-grass is the best pasture

plant. Johnson-grass and Bermuda-grass are grown for hay and pasture throughout this section. Both spread rapidly and are hard to get rid of after they have once been grown, so that they are looked upon as weeds.

On the gulf coast, crab-grass, beggarweed, Mexican clover, and carpet-grass supply most of the hay and pasture. In the Plains region, brome-grass is the most important hay and pasture plant, while millet and sorghum are valuable for rough forage. In the Rocky Mountain states, alfalfa (a legume) has first place, with timothy, orchard-grass, and clover of less importance. On the Pacific coast, alfalfa outranks all other hay plants.

In each section of the country, therefore, some hay plants are of much more value than others. An almost endless number of other grasses are grown, however. Taking the country as a whole, timothy is the leading hay plant and blue-grass the leading pasture plant.

Meadows. — By the word meadow we mean land on which grass is grown to be cut for hay. The land may be kept permanently in grass, or it may be plowed every two, three, or four years and a new meadow seeded on another piece of land.

Since the grass in the meadow is to be cut for hay, all of the plants should be at their best at the same time. The plants should also grow to maturity quickly. The farmer has to consider these points in choosing seed for his meadows. If the meadows are to be plowed frequently, the seed must not be very costly. One reason why timothy is so widely grown as a hay plant is that its seed is cheap.

Pastures. — By the word pasture we mean land on which grass is grown for grazing by live-stock. Pasture may be either permanent or temporary. When it is temporary, it is usually a meadow from which two or more crops of hay have been cut.

Since pasture is used for many months in the year, the grasses in it should not all mature at the same time. For this reason, usually a mixture of several kinds of grass seed are planted. Different

plants occupy the ground in different ways, and when more than one kind is planted, the land is used to better advantage. Then, too, if the season is unfavorable for one kind, it may be more favorable for some other kind. The farmer will choose the grasses which yield the largest crops in his locality and which his animals like.

Fig. 78. — Pasture on an eastern farm.

Timothy. — Timothy is the best known grass in the United States. It gets its name from Timothy Hansen, who took the grass from New York to the Carolinas about 1720. It was cultivated by him in Virginia, also. In 1760, Peter Wynch, President of the Agricultural Society of England, secured some of the seed from Virginia. It soon came into general use in England. It is a native of Europe, and is now grown extensively in western Asia and Africa, as well as in Europe and America.

Timothy is a perennial plant. It has short, flat leaves. On good soil it grows two to four feet high. Each stem bears a stiff, erect, rough spike or head as thick and generally as long as a lead

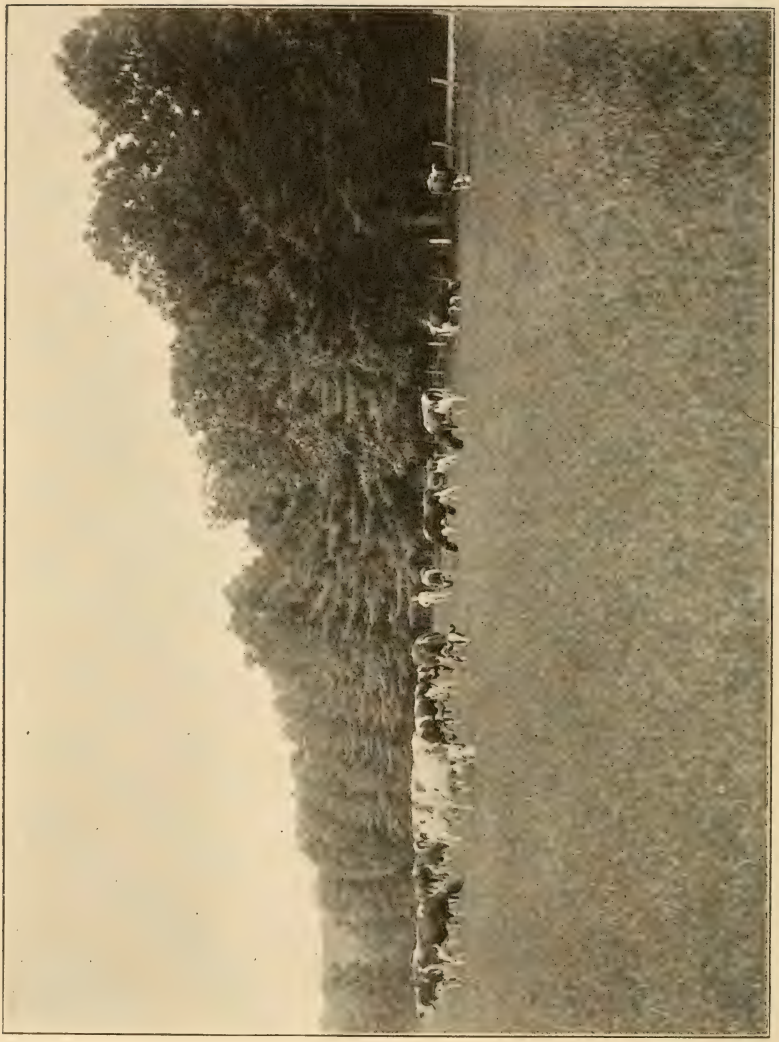

Fig. 79. — A bountiful pasture.

pencil. The grass stands up well and the hay is easily cured. It has a good appearance, and sells readily.

Timothy may be sown alone or in mixtures for meadows, but is of little use as a pasture plant. It may be sown in the fall with wheat or rye, or may be planted early in the spring. About eleven pounds of seed are used to the acre. It will grow on a great variety of soils, but grows best on clay loam.

FIG. 80. — Timothy hay plant, nine months old. Many shoots rise from the same roots.

Blue-grass. — This is one of the most common and most useful grasses in the north temperate zone. It is found in Great Britain, Asia, Australia, and America. In North America it is especially valuable for lawns and for permanent pastures in the northern states. It does not do well in the South. It yields a light crop. It makes good pasture from early spring to early summer, and again in the fall after the heat of summer is past.

Blue-grass varies in height from a few inches to a foot or more. Its head is light and spreading, and the seed is borne on little branches bearing three to five flowers. It spreads rapidly by underground branches or rootstocks, so that it gradually takes possession of the ground wherever it is planted. It grows in tufts or bunches.

Blue-grass is usually sown in the spring, and it may be planted early. Three to ten pounds of good seed to the acre is sufficient in pasture mixtures. As much of the seed on the market is poor, it may take more than this to secure a good seeding.

Problem 118. Bring to school as many different kinds of grasses as you can find in your locality. Ask the teacher to help you dry them and mount them on card-board for your museum or collection. Find some one who can name those that you do not know. Place the name of each one on its card. Study the different kinds until you know them all.

Problem 119. Name the different kinds of grasses sown by farmers in your locality. What is each used for? Do they all ripen at the same time? Which do the stock like best? Which kinds sell best?

Problem 120. Count the number of plants on a piece of pasture sod six inches square. If there are 43,560 square feet in an acre, how many plants are there to the acre? Kow many different kinds of plants are present on the piece of sod?

Problem 121. If a meadow yields two tons of hay which, by weight, is one fourth clover, one fifth weeds, and the remainder timothy, how many pounds of each are harvested?

Problem 122. What land on your farm is used for pasture? Why? Is it ever plowed and planted to some other crop? How often are the meadows plowed? What do they precede and follow in the rotation? Why?

Problem 123. Examine a load or mow or forkful of hay to see whether you can tell what kinds of grass and other plants it contains.

Problem 124. Can you tell what kinds of grass make up the pasture nearest the school-house? On your father's farm?

CHAPTER XXIII

CLOVERS AND THEIR KIN

MANY leguminous or clover-like plants are of great importance to the farmer, not only for their stock-feeding value, but also because they make the soil in which they grow richer. They all have the power of storing nitrogen in the nodules on their roots, as we learned in Chapter XIII. Every good farmer raises one or more of them. In the northern states, several varieties of clover are grown; in the western states and California, alfalfa is grown; in the central and southern states, soybeans, cowpeas, and crimson clover; in the south, velvet beans, beggarweed, and sweet clover or melilotus; in both the north and the south, vetch is grown.

Importance of the clover. — For many centuries, the most careful farmers have grown clover or a clover-like plant, because it seemed to make the soil more fruitful. Long before it was discovered how leguminous plants enriched the soil, it was known that they did so. Now that we know that clovers and their kin restore to the soil nitrogen which other crops have exhausted, farmers include a leguminous crop in their regular rotation systems.

Uses. — Clover-like plants are sometimes used to occupy the land for the short periods between the growing of other crops, so as to protect the soil, to make it richer by adding nitrogen, and to furnish vegetable matter when plowed under. For example, crimson clover may be sown in corn at the last cultivation. After the corn is harvested, the clover occupies the land, protects it during the winter, and in the spring is plowed in when the ground is prepared for the grain that is to follow.

Most of the clover-like plants are valuable for feeding to stock, because they are rich in protein, a substance containing nitrogen.

Fig. 81. — The common red clover.

Clover. — The American colonists cultivated the native grasses long before they began to grow clover. Red clover was not carried to England from the continent of Europe until 1633, yellow clover till 1659, and white or Dutch clover till 1700. These plants did not reach America until a much later period. Now they are widely grown, and are numbered among our most important forage plants.

Red clover came to us from Europe. It is native also to Asia. It is used more largely in hay mixtures in this country than any of the other clovers. It is really a perennial plant, although it may run out after the second or third year. It is a spreading, hairy plant,

bearing purplish heads or flowers on the ends of branching, leafy stems. The leaves have a prominent whitish spot.

This clover is easy to grow. It may be planted with oats or barley, but is commonly sown in the spring in winter wheat. When settled weather has come in the spring, the land is harrowed, and the seed sown and harrowed in. About ten pounds of seed to the acre is used.

The clover should be cut before it comes into bloom the first summer or it may not grow well the second summer. For hay, it is cut when the heads are in full bloom and before any of them have turned brown. Clover pasture is much relished by hogs, and cattle thrive on it if not allowed too much at a time.

Mammoth red clover is a perennial plant. It is less likely to die after the second or third year than is red clover. It grows taller and stouter than the common red, ripens later, and bears larger and darker heads. It yields more heavily than the common red clover, but stock do not like it so well.

Alsike clover was brought to America from Europe, and is now grown in low meadows and waste places from Nova Scotia to Idaho. It is a perennial that grows tall, has slender stems, and small whitish or rose-colored heads. The leaves are borne on long, forked stalks that rise from the low-growing main stem. It grows well on cool, moist soils and is valuable in wet meadows where red clover would be drowned. It is useful both for hay and for pasture. It makes a fine, soft hay. It is a valuable honey or bee plant also.

White clover was introduced from Europe, but is probably native to northern America. It is now grown in almost all regions in the temperate zones. Some persons think that it was the original shamrock. It is a low, creeping, perennial plant, that bears its small fragrant white blossoms on long, slender stalks. The leaves, which usually are made up of three leaflets, are also supported on long, slender stalks. The leaves and the flowers rise from the stem that creeps along the surface of the ground. White clover

will grow in cool climates and on moist soils. It grows so low that it is not useful for hay, but is a good pasture plant. It is much used for lawns, also.

FIG. 82. — A branch of the alfalfa plant.

Crimson clover had its original home in the Mediterranean region in Europe. It is an annual plant, erect, two to three feet tall, and is covered with soft hairs. The heads are oblong and dense, and are composed of brilliant crimson flowers The leaves are borne on long stalks. It grows best in warm climates, on loose, sandy soils. It is used both for hay and for pasture, as well as for green-manure purposes.

Alfalfa. — Alfalfa is native to the valleys of southwestern Asia. It was in use centuries before the Christian era. It spread from Persia to Greece about 480 B.C., then to Italy, Spain, Mexico, and South America. It reached Mexico and South America during the Spanish invasion in the sixteenth century. It was brought to New York from Europe as early as 1791. It was carried to California from Chile in 1854, and crossed from Mexico into Texas in

the early part of the nineteenth century. It has spread rapidly in the west and southwest, and is gradually becoming a valuable hay plant in other sections.

Alfalfa is a long-lived perennial plant. It roots very deeply, usually from 6 to 12 feet. Its stems grow 1 to 4 feet high, and

FIG. 83. — Stacking Alfalfa in the western country, where large areas are grown.

in bunches or clumps. The stems are covered with small leaves made up of 3 leaflets. The flowers are purple, or occasionally white, and are clover-shaped.

To grow alfalfa, a deep, well-drained soil, free from acid, is necessary. If there is too much acid, so that the soil is "sour," flooding the land or applying lime to it will remove the surplus acid. Well-rotted barnyard manure makes an excellent fertilizer.

The seed-bed must be made fine. The alfalfa seedling is not a strong plant, and it cannot compete with weeds until after it

has become well established. It demands plenty of moisture for its growth, but will not thrive in wet soils; it should therefore be planted on a well-drained soil. There must be the right kind of bacteria in the soil to store nitrogen in the nodules on the alfalfa roots. Frequently it is necessary to secure some soil from a field where alfalfa has grown luxuriantly in order to establish the bacteria in the new land.

In the West, 12 to 20 pounds, and in the East, 20 to 30 pounds, of seed are sown to the acre. Alfalfa grows rapidly and may be cut 2 or 3 times each season in the East, and four to seven times in the West. It will yield 4 to 5 tons to the acre. Fields may be kept in alfalfa as long as fifty or more years.

Alfalfa is a valuable hay plant, because it is rich in protein. It should be cut when it opens into flower. It makes good pasture if the stock are allowed to graze only a little at a time. It is useful in making the soil richer, because of the nitrogen gathered in the nodules on its roots.

Cowpeas. — The cowpea had its original home in India and the region to the north. It has been cultivated for two thousand years or more. Varieties have been distributed throughout the world, but only in China, India, and the southern part of the United States has it become an important farm crop. It reached the West Indies in the latter half of the seventeenth century, and was brought to the United States some time later. In recent years it has been grown to a considerable extent in the northern part of the United States.

The cowpea is a summer-growing annual plant, closely related to the bean. Some varieties are erect and bush-like, others are trailing. It is a climbing plant, and its slender runners twine around nearby objects. The leaves have each three leaflets, and in appearance are much like those of the garden bean. The flowers are whitish or whitish purple, and may have a yellow tint. The pods are usually straw-colored, and are 5 to 10 inches long.

Cowpeas will grow on almost any kind of soil except that which

FIG. 84. — Cowpeas growing between rows of corn.

remains wet during the summer. It likes a warm climate and is easily killed by frost. The soil should be well prepared by plow-

ing and harrowing. The seed may be sown broadcast or in drills. When sown broadcast, four to six pecks of seed are used per acre, and when planted in rows two to three pecks.

The leaves of cowpeas fall off easily when it is being cured, so that sometimes a grass crop, as German millet, is grown with it. The millet makes the curing quicker and entangles the leaves so that they are saved. Cowpea hay is allowed to lie where it is cut for 24 to 36 hours, after which it is raked and piled into cocks. If the weather is fair, the curing will be completed in the cocks in 2 or 3 days. Then the cocks may be opened for a few hours before being hauled to the barn.

Cowpeas are grown for hay, green forage, and to enrich the land.

Other clover-like plants. — The *soybean* is closely related to the cowpea. It is grown more or less throughout the eastern and southern parts of the United States. It is used for human food, for stock food, and to improve soils.

Vetches are grown both in the North and in the South as pasture plants for horses, cattle, sheep, and swine. They are frequently grown merely to enrich the soil.

Melilotus, the common "sweet clover" that grows by the roadside, is sometimes planted in the South to be used as a green-manure, forage, and bee plant. Generally it is looked upon as a weed.

Problem 125. How many legumes can you name?

Problem 126. Bring to school a plant of each of the clovers and other legumes that you can find. Mount them on cards for your museum. Compare them carefully and explain how they resemble each other, and how they differ. Compare the flowers especially. How do the stems of white clover differ from the stems of other clovers?

Problem 127. Are any of these plants grown on your farm merely to enrich the soil? What is a cover-crop and what are its uses?

Problem 128. Which is the better stock feed: timothy hay, clover, or alfalfa?

Problem 129. What kinds of leguminous plants run wild in your neighborhood? What kinds are cultivated?

Problem 130. Write a short essay about the use that is made of clove on the farm, and where it should come in the rotation system.

CHAPTER XXIV

POTATO

It is thought that the potato was cultivated in Peru at least 2000 years ago. When the Spaniards came as conquerors to South America, they found the Indians cultivating the plant in all the valleys of the Andes from Chile to New Granada (now Colombia). They carried it back to Spain with them, and passed it into Italy and the Netherlands before it was known in England. Both Sir

Fig. 85. — Potatoes.

Francis Drake and Sir Walter Raleigh are credited with its introduction into England. It was probably taken to Ireland in 1586 by Thomas Herriot, who was a member of the expedition sent to America by Sir Walter Raleigh. Raleigh cultivated it on his farm near Cork in Ireland. He called it Battata.

The potato has strongly affected the fortunes of English-speaking peoples. Its destruction by blight in 1846 was the cause of the

" Great Famine," which drove over the seas so many thousands of Ireland's best and sturdiest workers to help in building up America.

It is a common opinion that the aborigines of Virginia cultivated the potato at the time of the discovery of America. The crop was early grown by the Virginia colony. It was not grown in New England until the arrival of the Presbyterian immigrants from Ireland in 1718. The potato has been developed to a greater extent in Europe than in America, and is now a staple crop throughout both continents.

Place of the potato in agriculture. — Next to rice, the potato is probably the most extensively grown and most valuable crop in the world. The annual yield of the world is nearly 5,000,000,000 bushels. The potato crop of Europe alone is greater in value than the reported wheat crop of the world. One acre of potatoes frequently furnishes as much human food as ten acres of wheat.

As potatoes are a cultivated crop they fit well into rotation systems, to follow the grass and precede the small grain.

The potato plant. — The potato is a plant having a weak stem, branches of which may grow long and trail on the ground. The the stem is round and smooth, and all parts of the green plant are juicy. The leaves grow alternately and are compound, a pair of very small leaflets growing between pairs of much larger size.

In some varieties the slightly fragrant flowers are light purple or lilac, in others they are white. The fruit or seed-ball is round and about the size of a small plum, and of a yellowish color when ripe. It is packed full of seeds shaped very much like tomato seeds, but smaller.

The part of the potato that we eat is an enlarged underground stem called a tuber. We might think from its appearance and from the fact that it is produced beneath the surface of the ground, that it is a root ; but when we study it, we shall find it is not. In the first place, although the tubers differ greatly in size, shape, and color, they are all alike in having "eyes" on their surfaces. These are fewest near the stem end, where the

tubers are fastened to the plant, and are very numerous at the opposite or "bud" end. When the potato is allowed to sprout, we discover that each eye is a leaf-bud from which a leaf-growth springs. We know that leaves grow from stems only, and not

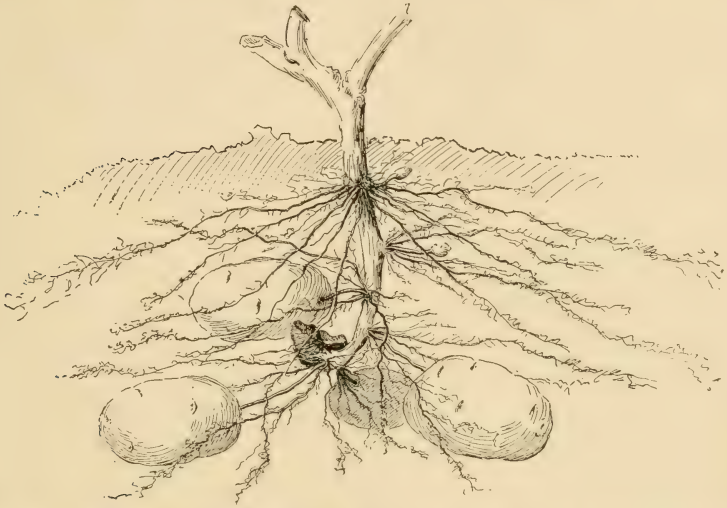

FIG. 86. — The underground parts of the potato plant in a loose, mellow soil, showing the tubers and the true roots.

from roots; therefore, the potato tuber cannot be a root. It is part of the stem underground, enlarged for the storage of surplus plant-food. In the second place, rootlets are never attached to the tubers of the potato, but to the main root-stem of the plant itself.

Culture. — In its wild state the potato reproduces itself through the seeds which are borne in the seed-ball at the end of the stalk. The seeds from any one plant, however, may produce several varieties of potatoes, so that the farmer cannot depend on the seed for his new crop. The tubers will produce plants bearing other tubers just like themselves, so the farmer plants tubers or parts of tubers for his new crop.

Each eye of the potato will develop a leaf-bud and put forth rootlets. If a piece large enough to nourish the young plant until it becomes established is used, a stronger plant will result. Potatoes which have sprouted in the cellar or pit, sending out long, colorless shoots, should never be used for planting, as the tubers have been robbed of that much plant-food.

Ideal conditions for the growth of the seed are a moderately moist and deep, fertile soil, and a relatively cool climate. The seed is planted two to four inches deep. The most successful potato growers do not hill up their plants, at least not until late in the season, but keep the field level. Level culture wastes less moisture than hilling.

A few days after planting, the spike-toothed harrow or the weeder should be run over the field to destroy all weeds before they are well started. Then the weeder may be used once a week until the plants are seven to ten inches tall. Thereafter, about five cultivations should be given at intervals of seven to ten days.

Early potatoes are dug as soon as they are large enough to sell. Late varieties are left until the vines are dead. The potatoes should be harvested when the land is dry, and the tubers picked up at once and kept in a cool place.

The average yield of potatoes in the United States is about 85 bushels per acre, but under ideal conditions 300 to 500 bushels per acre is not uncommon.

Fig. 87. — The potato beetle.

Enemies. — The first enemies of the potato plant to appear are leaf flea-beetles. They arrive as soon as the plants are above ground. They gnaw small holes in the leaves. Repeated spraying of the vines with Bordeaux mixture combined with Paris green will check this destroyer. The same remedy should be applied for the black-and-yellow coated Colorado potato beetle.

The diseases of the potato may be more destructive than its insect marauders. The early blight, which usually appears in June, may destroy some of the foliage and check the growth. The late blight is much more serious. The vines may be so badly injured that no tubers will be formed. Spraying with Bordeaux mixture is the remedy.

Scab and rot are diseases that attack the tubers underground.

FIG. 88.
The flower and leaf of the sweet potato plant.

FIG. 89. — A field of sweet potatoes.

They, also, may be very destructive.

Uses.—Potatoes are used most largely for human food. They are also valuable for stock-food, either raw or cooked. From the tubers, starch and alcohol are made.

Sweet potatoes. — The sweet potato, which is a staple food crop in the South, differs from the Irish or white potato in that it is a true root and not an enlarged underground stem or tuber.

It has no eyes, no leaf-buds. Small rootlets run out from it. It belongs to the same family of plants as the morning-glory, and the flowers resemble those of the morning-glory.

The sweet potato probably had its original home in tropical America. It is now in cultivation in many of the islands of the Pacific. It is reproduced by planting the sweet potato, which is a true root, as we learned in Chapter XVIII.

Problem 131. Dig up an entire potato plant without breaking off the tubers, and examine it in the field or bring it into the schoolroom. Where are the true roots? What is the difference between them and the stems on which the potatoes are borne? How many potatoes grow on each stem? Do the true roots go much deeper than the tubers? Are any rootlets attached to the potato as to beets, turnips, or sweet potatoes? What does this indicate?

Problem 132. In a box in the schoolroom plant one whole potato, one piece having two eyes, and one piece having no eyes. Mark the place where each is planted. Do they all grow? If not, why? Which develops the best plant?

Problem 133. In another box, plant a large piece of potato having only one eye. As soon as the rootlets begin to appear divide the eye and piece into two parts and re-plant. In a few days after the rootlets have again started, divide the two pieces into four and re-plant. See how many times this can be repeated, and how many potato plants may be grown from one eye. When large enough, set these little plants in the school-garden, if the weather is suitable.

Problem 134. Purchase at the drug store five cents' worth of iodine (*a poison*). Dilute it one half with water. Cut a few slices of potato and apply a few drops of iodine to the freshly cut surfaces. The color will change to a blue-black. This shows that the potato is composed of stored up starch. When iodine touches grains of starch, they turn to a blue-black.

Problem 135. Describe the difference between the common or white potato and the sweet potato.

Problem 136. How many kinds of potatoes do you know? How do you distinguish them?

Problem 137. How does your father keep or store his potatoes?

Problem 138. How much are potatoes worth in the market at present?

CHAPTER XXV

THE ORCHARD

NATURE has generously provided many kinds of fruit, and many varieties of each, so that some sort will grow in nearly every section of America. Nearly all farms have some fruit. There may be only a few trees for family use, or there may be orchards that cover many acres. In the latter case, fruit-growing is an important part of the farm business. It may be the largest part of the business.

Location of the orchard. — Fruit may be grown for a few years on almost any kind of soil. But if we would grow long-lived trees and fruit of superior quality, then the climate, site, and soil must be favorable. The site is the place where the orchard is to be planted.

There may be more than one site on the farm for the orchard, the main difference between them being the slope. South and west slopes are hottest in summer and are subject to more sudden weather changes than north or east slopes. On south slopes, peach trees may be brought into blossom earlier than on north and east slopes; consequently they are more liable to early frost injury. On the western plains, the best growth of native timber is always on north slopes.

In general, we may say that for apple, pear, and plum trees, a location that slopes to the southwest, west, or northwest, is best; peach and cherry trees seem to prefer a northwest or west slope.

The choice of the soil is as important as the choice of slope. A rich, deep, moist clay loam is ideal for apples, pears, and plums,

and a light, sandy loam is preferable for peaches and cherries. If the prospective grower has no choice of soil, and must take a less desirable kind, he may still grow fruit for home use.

The soil should be prepared as carefully for the fruit crop as for the corn crop, so that the roots may run far and wide in search of food and water. Frequently it will be necessary to drain the land, as fruit land must not be wet. For best results the soil must be pulverized, drained, and deepened.

Planting the trees. — On a well-fitted soil, the first essentials for success are the trees. They should be purchased from a reliable nursery as near home as possible so that they will be accustomed to the climate of the region in which they are to be grown.

The trees may be planted either in fall or in spring. The rows should be straight, both for appearance and because tillage will be easier. The trees must be set far enough apart so as to make the best growth. The distance will vary. A common distance is to plant apple trees 40 feet apart each way, pears 20 to 25 feet each way, quinces 16 feet, plums 20 feet, sour cherries 20 feet, sweet cherries 30 feet, peaches 20 feet.

When the trees are dug from the nursery, many of the roots are destroyed. If all of the top is left, there will be a greater demand for plant-food than the roots can supply. Usually the top is cut back severely, so that only a " leader " and three or four short side branches are left.

A hole is dug sufficiently large to accommodate the roots comfortably in their natural positions. Fine, rich soil must be worked firmly about the roots so that they can begin their activities at once. A shallow layer of loose soil is left on the surface as a mulch. Coarse, fresh stable manure should not be placed in contact with the roots.

Tilling and fertilizing. — Orchard trees grow large and are expected to bear heavy crops of fruit year after year. To do this, they must receive good care and abundant plant-food.

We know that tillage improves texture, saves moisture, and sets free plant-food. It is therefore a very important operation in the orchard. Over 90 per cent of most fruits is water. To obtain a large crop there must be a great abundance of moisture in the soil. In dry seasons, the moisture must be prevented from escaping from the soil. The apples on sod land are likely to be much smaller and poorer in a dry summer than those grown on tilled land.

The orchard may be plowed first thing in the spring to break up the soil. During the summer the harrow and the cultivator should be used to preserve the surface mulch.

Fig. 90. — The Baldwin apple.

Trees make heavy demands on the plant-food in the soil, so that it is seldom wise to grow any other crop, even grass, in the orchard. The soil will need to have humus added to it from time to time. This may be done by applying barnyard manure or growing a cover-crop. It may be necessary to add commercial fertilizers containing nitrogen, phosphoric acid, and potash. Stunted growth indicates the need of nitrogen, or water, or both. Fruit lacking in flavor and color suggests that phosphoric acid and potash are needed.

Pruning and spraying. — Tilling and fertilizing are only part of the care of the growing and bearing orchard. They make the tree grow. Pruning and spraying direct the growth and protect the tree from injury by insects and diseases.

A wild, uncared for tree seldom produces good fruit. It may produce very many small fruits. The fruit-grower desires large, well-shaped and well-colored fruit that will be attractive on the

market. To obtain it, he keeps his trees vigorous, and removes unproductive and interfering branches.

Pruning helps to make a tree vigorous; it also changes the shape of the tree to suit the wishes of the grower. Winter pruning encourages the growth of wood, while summer pruning encourages the production of fruit.

Young trees that were properly pruned when set out will require little pruning until they begin to bear. Shoots that would

Fig. 91. — Picking Baldwins. The fruit-grower has his busiest season at the harvest time.

make a poorly shaped head, or that cross and interfere with other branches, should be removed. In pruning old fruit trees, the aim should be to prevent crossing and crowding of branches and to thin out old wood, so that young, vigorous wood may take its place. When the ends and highest branches are cut back, growth is formed in the lower branches.

All fruit trees have enemies, both insects and diseases. They

FIG. 92. — Packing fruit for market. (p. 181)

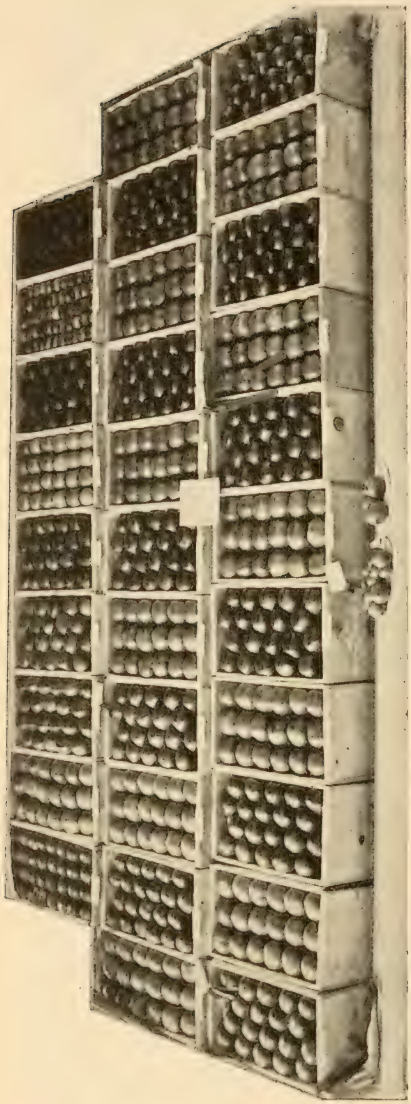

Fig. 93. — Apples packed for market. The box is taking the place of the barrel.

must be controlled if good fruit is to be grown. This is done partly by spraying. Some kinds of sprays are used for insects, and other kinds for diseases. We shall learn more about spraying in Chapters XXIX and XXX.

Harvesting. — If the grower is to secure part or all of his income from his fruit, the harvesting and marketing become very important. The fruit should be picked, not pulled, and handled carefully to prevent bruising. It should be graded according to size and quality before it is packed, so that each barrel or box will be uniform throughout. When this is done, it is attractive to the buyer. Neat packages and careful packing add to the selling price.

Kinds of fruit. — The more important orchard fruits in America are apples, peaches, pears, plums, cherries, oranges, and lemons. The apple is the king of all fruits in this country.

Apples. — From time immemorial the apple tree has been cultivated by man. Its original home was in southwestern Asia and southeastern Europe. It is now grown in every temperate climate and is the most important tree fruit.

Apple orchards were common in the American colonies, and shiploads of apples were exported to the West Indies. The first trees in New England were planted on Governor's Island, Boston Harbor, from which " ten fair pippins " were picked on October 10, 1639. An apple nursery was planted on the farm of Governor Endicott, at Salem, in 1640. In 1641, apple trees were planted on Governor Berkeley's farm in Virginia.

The best apple region in America is a stretch of country beginning with Nova Scotia and extending west and southwest to Lake Michigan. Many other sections are well adapted for this fruit.

North America is the leading apple-growing country in the world. A full crop of all kinds and grades for the United States and Canada is probably not less than 100,000,000 barrels.

Apple stocks are grown from seeds. At the end of a year, or a little longer, the desired variety is budded or grafted on to the stock in the nursery row. The trees are set in the orchard when two or three years old.

Peaches. — The peach probably had its original home in China. It has been in cultivation from the earliest times. It came into Europe by way of Persia, and from there reached America. As early as 1629 peaches were grown in Virginia, and before the Revolutionary War New Jersey and Delaware were famous for their peaches.

The peach is tender to frost, and is not so easily grown as the apple. It grows best in mild climates, near bodies of water. There are " belts " along the Great Lakes, in Connecticut, in the South Atlantic States, in Illinois westward to Missouri, southeastern Texas, western Colorado and California, where peach-growing is specially successful.

The peach is propagated by means of seeds. The first year the seedlings are budded in the nursery to the desired variety. A year later they are ready to plant in the orchard.

Pears. — The pear is a native of Europe and was introduced into America by the colonists. It is now grown in many parts of the temperate zone, but the largest production is in France and the United States. In America, the best pear regions are in the northeastern states, from New England west to the Great Lakes, and in California and parts of Oregon and Washington.

Pear seedlings are grown in the same manner as those of the apple. The young trees are ready for the orchard two or three years after they have been budded in the nursery row.

Plums. — Many varieties of plums are grown in America, which came from different original ancestors. Some had their first home in southeastern Asia, some in western Asia, some in southeastern Europe, some in America, and others elsewhere.

The seedlings, grown from the seeds, are budded at the end of one or two years' growth. Plums may also be grown from "suckers," or shoots, which spring from the roots.

Cherries. — Most of the cherries grown in America have come from plants that are native to Europe. Cherries are not grown as an important farm crop east of the Rocky Mountains, except in western New York, where the sour varieties are grown for canning.

Cherries are raised from seeds, and the seedlings are budded or grafted to the desired variety, much the same as apples.

Problem 139. Can you tell the difference between apple, peach, pear, plum, and cherry trees in summer? How? In winter?

Problem 140. How many different kinds of fruit that are sold in your locality are brought from other sections of the state or country? Where do they come from?

Problem 141. If yours is a fruit-growing region, what is done with the fruit that is grown? Is any of it dried? Is any manufactured? Is any made into cider? Where is the cider sold, and for what purpose?

Problem 142. Name three fall apples, and three winter apples. Describe them.

Problem 143. Describe in detail how apples are picked, packed, and stored.

Problem 144. Are there orchards in your locality that are cultivated? Do they seem to yield better crops than those in sod? Is there any difference in the health of the trees?

Problem 145. What difference is there between the orchards that are sprayed and those that are not sprayed? For what things are they sprayed?

Problem 146. When is pruning done? What parts of the tree are removed? Why?

CHAPTER XXVI

THE FARM GARDEN

EVERY farm should have its garden-spot. Many of our schools have gardens, and some day all good country schools will have

FIG. 94. — Staking out the school garden.

gardens in which boys and girls will study how vegetables and flowers grow. They will learn how to prepare the soil, how to plant and care for the seeds and plants, what their needs are, and how to supply them. The garden is simply a miniature farm, in which plants

receive individual attention. It should be the most productive area on the farm. Usually it is the least productive.

Location of the garden. — The farm garden should be placed near the house, because it is truly the " kitchen " garden and should be easily reached from the kitchen. It should be large enough for the crops to have an abundance of room, and so that horse-cultivation may be given instead of hand-cultivation. Long rows, or an oblong garden instead of a square one, make horse-cultivation easier. The vegetable garden may be a part of a field crop, as corn or potatoes, the vegetables being planted at the ends of the field rows so that both crops may be cultivated at once.

The soil. — If we are starting the garden on new ground, we must first put the soil in good condition by plowing under a liberal quantity of stable manure, or by planting a cover-crop to be plowed under the season before the garden is to be made. A dressing of five to ten loads per acre of fine, rich stable manure should be worked into the soil with a disk or spring-tooth harrow. If stable manure cannot be had, a good commercial garden fertilizer may be used at the rate of one half to one ton per acre, or 50 to 120 pounds per square rod. Vegetables must grow rapidly, and so the soil must be rich. A small, rich garden is much more satisfactory and less expensive than a large, poor one.

If the location of the garden can be secured in the fall, much of the preliminary work, as leveling, the removal of rough material, and the ploughing or spading, may be done before freezing weather. Fall plowing is to be recommended, as winter freezing has a beneficial effect on the soil, causing it to crumble and separate into fine particles. It is possible also to work fall-plowed land earlier in the spring than unplowed land. If spring plowing must be done, it is best to begin as early as the ground will permit. It is well to plow to a depth of four to six inches and to harrow the soil fine with a spring-tooth harrow, after which the small stones and rubbish may be raked off with a hand rake, and the ground leveled for sowing seeds.

Heavy clay is not the best soil for gardens. If such a soil must be used, it should be drained, and muck, grass, sand, or coal ashes added to lighten it. Clay should never be plowed when it is wet. Gravelly, sandy, and clay loams are easy to work and are good garden soils.

Sowing the seeds. — The entire garden need not be planted at one time. If radishes, lettuce, and peas are planted early, they may be harvested in time to plant sweet corn, cucumbers, squash, late beets, cabbage, and other crops in their place. After early beans, sweet corn, and potatoes, we may plant celery, turnips, spinach, and the like. Usually it is desirable to have a succession of sweet corn and peas. In order to do so, early, medium, and late varieties are planted at one time, and some good variety is planted every week or ten days for a few weeks thereafter.

In planting the seed, it is much better to sow in rows than broadcast. The seedlings may then be more easily distinguished from one another, thinning and weeding may be quickly done, and the soil between the rows may be hoed without injury to the seedling plants.

It is best, if possible, to have the rows extend north and south; this will give each row its share of sunlight. If the rows run east and west, and one or more rows contain tall plants, there is danger of shading the rows in the rear.

Watering the garden. — If it is necessary to water the growing plants, it should be done late in the afternoon, if possible. If watered in the morning, the sun causes very rapid evaporation, leaving the soil dry, and causing heavy soils to bake.

As we have learned, thorough cultivation of the soil will hold the moisture in the soil and lessen the need of watering. Much of the watering in gardens may be done by the rake. With the rake we can create a fine, loose, dry mulch which will keep the water from escaping by evaporation. A mulch may be made, also, by spreading on the ground grass, hay, straw, coarse manure, leaves, or boards.

Starting the plants. — The seeds of all but the coarser growing plants may be started in the house in March or April, by using shallow boxes or trays filled with light soil. Care is needed not to sow the seeds too early, for if the plants grow spindling they will be difficult to transplant. Six weeks before the time to plant outdoors is early enough to sow the seeds in boxes, and even then it may be necessary to transplant to other boxes before the ground is fit to receive the seedlings.

Planting out-doors. — With a fine, mellow seed-bed, the seeds should be covered according to their size and the weather conditions. Small seeds should be covered three or four times their thickness in dry weather, and less deeply in wet weather. The soil should be pressed firmly about the seed with the hands, foot, or hoe.

Care of the garden. — The garden demands careful attention throughout the summer. Weeds must be kept out, the surface soil must be loose, and the plants must be protected from destructive insects and diseases. Many enemies will come upon the garden to destroy it. For insects that bite or chew the leaves, hellebore, Paris green, arsenate of lead, and other poisons may be used. For insects that puncture the leaves and suck its juices, whale-oil soap, kerosene emulsion, and lime and sulfur wash, are valuable. For blights, rusts, and rots, Bordeaux mixture is the best protection.

FIG. 95. — Pigweed, or lamb's quarter. A common weed in gardens.

Harvesting. — Early vegetables should be harvested as soon as they are large enough for table use. Radishes, beets, turnips, and kohlrabi become woody if left in the ground too long. Lettuce, spinach, cabbage, and cauliflower will run to seed if left after they are fully mature.

Winter vegetables should be fresh and tender when gathered, and should be stored in a cool, moist place at a temperature of about 32 or 33 degrees. Beets, parsnips, and similar crops may be packed in cool, slightly moist leaves. Such leaves may be gathered in the morning after a frost or when there is a light snow on them.

Small fruits. — The garden will not be complete without its strawberries, blackberries, raspberries, currants, and gooseberries. These, also, should be planted in long rows, wide apart, so that they may have horse-cultivation and not be crowded in their growth.

Strawberries will yield as large a crop to the acre as apples. They do well on new land that has grown a crop of potatoes or some other hoed crop. The soil must be carefully prepared and all weeds kept out. Usually only one or two crops are gathered from the strawberry bed and then a new one is made. In the north the plants must be protected during the winter. A light covering of straw, old hay, strawy manure, pine needles, or other light material will serve for this purpose.

Raspberries, blackberries, currants, and gooseberries do best on loose, deep, rich loam soil, but may be grown on others that contain plenty of vegetable matter. New plantations may be made every six to ten years. The best time to plant is in the fall. Raspberries and blackberries are pruned each year by removing the canes that have borne fruit as soon as the fruit is gathered. In pruning currants and gooseberries, wood more than three or four years old is removed, so as to encourage the growth of new canes.

Problem 147. How many farmers in your neighborhood have gardens? What are the six crops mostly grown in them?

Problem 148. Is the same land on your farm used year after year for

the garden? If so, how it is fertilized — with barnyard manure, commercial fertilizers, or green-manures?

Problem 149. Is commercial fertilizer applied to some crops and not to others? What kind of fertilizer is used for each of the particular crops? Why is it used?

Problem 150. What kinds of root crops are grown in your farm garden? What kinds of vine crops? What kinds of crops are grown for their leaves? Which crops are planted earliest? Which latest?

Problem 151. Describe the different ways in which a garden may be watered, or the water made available to the plants.

Problem 152. In the spring, lay out a garden on the school grounds, at one side where it will not interfere with the playground. It may need a good dressing of barnyard manure. Let each member of the class have a share in it, for which he is especially responsible. Plant lettuce, radishes, peas, strawberries, sweet peas, and China asters. Take special care and pride in each step in the work — preparation of the soil, straight, even planting, grouping each crop by itself, a fine, clean mulch, freedom from weeds. Compare the school garden with the home garden. See how many ideas you can carry from the school garden to the home garden.

CHAPTER XXVII

THE WOOD CROP

Trees grown in the farm woodlot are as truly a farm crop as corn or cotton. They are planted, harvested, and used to supply human needs. If the woodlot is mismanaged, it will return a poor crop, just as will the wheat field. Most farm woodlots are poorly managed, and farmers are thereby wasting an important source of income.

Importance to the farmer. — It is estimated that the farmers' woodlots of the country alone are capable of growing more timber than our present total consumption. In 1900, over $100,000,000 worth of wood was cut on farmers' woodlots, and about one third of the area in farms was in wood.

The farmer himself uses considerable wood. It is his usual fuel, and supplies material for fences, buildings, and many other purposes. If the farmer cannot get what wood he needs from his own farm, he must either go without or be put to much expense. It is important, therefore, that in the East, the farmer know how to grow the largest and best wood crop, and in the West, where timber frequently is scarce, how to choose and plant trees that will supply his needs.

In some places, woodlots are useful to protect buildings and live-stock from driving winds. On the treeless plains and prairies, trees are sometimes planted for this purpose alone.

The loose, deep vegetable mulch in a well-cared for woodlot or forest will hold a large part of the water of rains. As this water drains away slowly, floods are prevented and a continuous supply of water is made available in streams.

The farmer should look upon his wood crop as one of his regular farm crops. He should give it a share of his attention. As he does not harvest the entire crop at one time, he must know when and where to cut so as to leave the remainder in the best condition to encourage the growth of young trees. He must know what kinds of trees will grow best in his locality, what each is useful for, how it behaves toward other trees in the forest, how long it requires for growth, and other similar facts.

Place on the farm. — Trees will grow on land that is useless for general farm purposes. On most farms there are some soils that are fit only for timber crops. By leaving this land in timber, or planting it to trees, the farmer has made his best investment in that land. Farms are sometimes deserted or abandoned because they will not produce good farm crops. Very often such farms are naturally well adapted for the growing of trees.

Lumbering is generally done in winter. The farmer who has a large, well-kept woodlot will be able to use his help in the woods in winter when general farm work is light. The care of the woodlot fits in well with other work, as it can be done at odd times. A few months' difference in time in cutting the wood crop will not injure it.

History. — The farm woodlot is almost everywhere the remnant of a large forest that once covered the region. When the early settlers from the Old World landed on the Atlantic coast of North America, they found a country almost covered with dense forests. There was little open land for the growing of crops. While the forest gave the settler fuel and shelter, and provided him with game, yet it was too often filled with hostile Indians, who, from its cover, dealt death to the settler and his family and destruction to his home. Instead of being an aid and protection to him, it became an object of fear. How to make a clearing most rapidly was the important question.

When the settlers in the northeastern states hewed their farms out of the forest, turning into pasture and field a large part of their

holdings, they left parts uncut for their own wood supply. This was to furnish fence-posts and rails, repair wood for buildings and implements, and, above all, firewood. In 1681, an ordinance of William Penn, intended to protect the forests, required that one acre of land be left in trees for every five acres cleared. This was not faithfully obeyed.

The better land was usually cleared first, and the woodlot left on the poorer lands and hillsides. The fact that the land was unsuited for farming or inconveniently located was doubtless important in determining what land should be left in trees.

From the first, land-owners mismanaged their woodlots, or did not manage them at all. Instead of taking out the dead and dying, the crooked and inferior, trees and limbs for firewood, they thought the best trees none too good for the fireplace. The best trees of the best kinds were cut for posts, fence-rails, fuel, and other inferior purposes. Consequently, the woodlots were left with the undesirable and useless trees. There was no thought as to the new crop to take the place of the old one. Cattle roamed in the woodlots, trampling the soil and destroying the young seedlings. In this unfortunate condition we find a large part of the woodlots on American farms to-day. The time has now come when the wood crop must receive attention and be made productive.

Distinction between field crops and wood crops. — While the products of both field and woodlot are farm crops, they have not much in common. Wood crops require years to develop. They do not have signs to show when they should be harvested. The wood crop is not necessarily reproduced by cutting and re-planting, as is usual with farm crops, although this may be done. The wood crop is not fertilized and cultivated as are field crops.

Field crops are dependent on the weather, while wood crops are not greatly affected by the weather and are seldom a total failure. The work on the wood crop may be done at almost any time of year, whereas general field crops demand attention at particular times.

FIG. 96. — The forest has overgrowth and undergrowth. (p 195)

The nature of the wood crop. — There is great variety in wood crops, as in field crops. There are many kinds of wood and many forms of growth. Conifers, or evergreens, as pines, spruce,

FIG. 97. — Sometimes trees are planted merely to break the force of the wind. This windbreak protects the orchard.

hemlock, fir, larch, cedar, and the like, furnish building materials. They grow from seed only and require a long time to reach suitable size. Broad-leaved trees, as maple, oak, hickory, and chestnut,

used for a variety of purposes, often are ready much sooner than conifers. They will reproduce by sprouting from the stump as well as from seed.

The battle of the trees. — The forest is a society of trees. If we go into a high woods in winter, and look up, we shall see that the crowns of the trees fill all the space overhead. The large trees have struggled to get ahead of each other and to spread their tops in the light. The lower branches have been shaded off, and the long, clean trunk, or upward-stretching branches, with narrow crown lifted high in the air, has been developed.

FIG. 98. — Transporting logs by sled.

In an opening in the woods, where large trees have been taken out, we may find a heavy growth of bushes and whips, struggling to get ahead of one another and to occupy the best places. Those that have broken through the tangle below are racing with each other to fill the open space with branches. When their branches meet and the crown is again formed, the shade deepens, and the weaker of the whips and saplings below will give up the battle and die. Some of the bushlike plants, however, continue to grow in dense shade; but they are not the kinds that become large trees.

The trees that forge ahead are said by the forester to be *dominant;* that is, they dominate or overshadow others. Those struggling just below are said to be *intermediate.* Still others, hopelessly beaten and overtopped, are said to be *suppressed.*

Some kinds of trees, losing in the struggle, are *tolerant* or shade-enduring. They are able to withstand the dense shade. They hold their places and wait patiently for the time when their immedimediate superiors shall be removed. Still other kinds do best in shaded conditions, and never enter the severe struggle for the highest places. They will always be found among the lower-growing trees and bushes in the woods. A forest, therefore, may have several stories of bushes and trees.

The care of the woodlot. — If the farmer cuts the most valuable trees year after year, his woodlot will constantly become poorer.

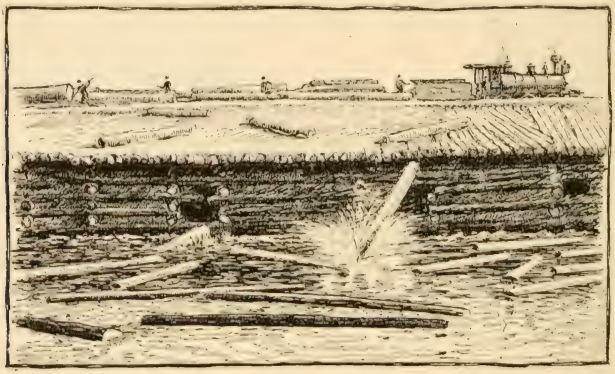

FIG. 99. — The transportation of logs by both steam cars and water.

The trees that he does not want will tend to take the places of those he cuts.

In order to keep the woodlot at its best, the dead, or dying, and undesirable trees should be removed for firewood, posts, poles, and similar uses, and only the mature trees cut for building purposes. The spaces thus left open should be filled by natural growth or by planted seedlings. The felled trees must be carefully removed so as not to destroy seedlings.

If the young growth is too dense, it may be necessary to remove some of the young trees. Sometimes it is desirable, also, to re-

move limbs or parts of trees that interfere with the best growth of the tree itself or of others near it. When a person thins his woodlot he must have in mind the best development of the trees that are to be left.

The woodlot should be protected from fire and from grazing and browsing animals. As fires are difficult to control after they have started, precautions must be taken to prevent them. If the woodlot borders the railroad, a cleared strip along the roadside is a safeguard. Such strips, or "fire lines," should be kept clean. Persons should be warned against starting camp fires in the woods. In removing trees in winter, the brush should be piled and burned; it should never be allowed to remain through the summer.

Cattle, sheep, goats, and hogs should not be allowed to run in the woodlot where a new growth is desired. By eating the leaves and tramping the ground they destroy the young trees. Frequently woodlots are ruined by allowing stock to run in them.

Forestry. — The raising of timber-crops, and the management of forests, is known as "forestry." It is a great branch of agriculture (or the producing of things from the land). It is recognized as such by the government in making the subject a part of the United States Department of Agriculture. In the heavily wooded regions, as in the East, forestry is important first of all in properly managing the forests; in the treeless regions, as in parts of the West, it is important in the planting of forests.

Problem 153. If there are woodlots on the farms in your locality, tell whether they are on land that would be useful for farming purposes if the trees were removed. Why have they been left, or planted, on the land they occupy?

Problem 154. Ask the teacher to take the class on an excursion into the woods. Plan to visit two woodlots, if possible, one that has a heavy young growth and many large trees, and one in which cattle have browsed. Note the differences in the large and the small trees, and in the soil cover. In which is the soil cool and moist?

Problem 155. Name all of the ways in which wood from the woodlots is used on the farms in your locality. Does it pay the farmer to keep his woodlot in good condition?

Problem 156. Write a list of as many trees in the woodlot as you can name, and tell for what the wood of each is used.

Problem 157. During a heavy rain, when the bare hillsides wash, what becomes of the water that falls in the woodlot? How long after the last snowfall have you found small patches of snow in the woods? Is the fact that forests hold the snow and allow it to melt gradually of any importance to the farmer?

Problem 158. Of what timber is the school-house made? Where did it come from? Of what is your residence made? Your barn? The fences?

Problem 159. What is the best timber for fence-posts? Why? Where do the fence-posts in your neighborhood come from?

CHAPTER XXVIII

FARM WEEDS

Weeds are plants that are not wanted. They are out of place. They may be either plants for which no use has ever been found, or those that are regularly cultivated on the farm. If they are a nuisance and are occupying space where they are not wanted, or that is needed by crops, they are weeds.

The farmer has never found any use for thistles or ragweed. They creep into his fields and interfere with his growing crops. He thinks of them always as weeds. Daisies and buttercups have attractive flowers, but when they establish themselves in the farmer's hayfield among the timothy, they are undesirable weeds. When timothy, in return, appears in the flower-garden, it is just as bad a weed. It is not wanted there and is out of place. Potatoes may be weeds in cornfields, or corn may be a weed in potato fields.

Why weeds grow. — If we go out on the farm to a plowed field that has lain idle for a year, we shall find that it is more or less covered with weeds. When the farmer ceased to give the field attention, Nature clothed it with herbage. Nature will not long allow the land to remain bare if it is possible to cover it. She is always ready with a seed to grow at the first opportunity. It is one of her practices to keep the earth covered, during the growing season, with some kind of plant. The plants that she establishes in our fields, however, we are likely to call weeds, because they usually come where we do not want them.

Why weeds are objectionable. — As we learned in Chapter XVII, more seeds are produced by plants than can find room to grow on the surface of the earth. There is a struggle among them for room, and for place.

FIG. 100. — A pigweed growing alone, showing spreading habit. The pigweed is a very common nuisance.

Weeds enter into this struggle. Always having had to look out for themselves, without the aid of man, many of them have become vigorous and persistent, and will struggle hard to keep their places. Because they are useless to the farmer and tend to crowd out plants that he desires to grow, they are objectionable to him.

Again, weeds require the same kinds of food for growth that other plants need. When they grow in a field of corn, for example, they take from the soil both moisture and plant-food that the corn plants should have. They may take so much moisture that in a dry season the crop of corn will be able to make only a short, stunted growth.

The greatest objection to weeds is that they take moisture and plant-food that the farmer's crops should have.

FIG. 101. — Pigweeds growing in a colony, showing narrow, erect growth from crowding.

How weeds increase. — Weeds appear everywhere, and in great numbers. There is never a time when a farmer does not have

them to contend with. He may spend much time in destroying them, but they soon appear again.

All of our common weeds produce seeds, some of them in very great numbers. Others are too impatient to wait for the seeds, and during the growing season send out runners, as does the strawberry, to start new plants. Orange hawkweed, sometimes called paint-brush, is a weed of this kind. Its runners are below the surface of the soil, as they are in the case of blue-grass. They send up new plants every two or three inches.

Fig. 102. — Wild carrot, establishes itself in pastures and neglected fields.

Certain other weeds will grow from parts or pieces of root, so that if any of the root is left in the ground a new plant will spring up. Horse radish, for example, which may sometimes be a weed, will produce new plants from the very smallest pieces of root.

When we add to the fact that weeds will grow from many parts of the plant, the additional facts (given in Chapter XVIII) that they employ almost every conceivable means of spreading their seeds, it is little wonder that they are so plentiful.

The control of weeds. — War can be waged against weeds most successfully when we know something of their habits, especially how long they live and how they spread.

Annual weeds, that is, those that live but one year, come up in the spring or summer, produce seed, and die in the autumn. They reproduce themselves only by seed. The seed lives in the ground over winter and grows in the spring. If annual plants are not

allowed to produce seeds, therefore, they will be utterly destroyed. Such weeds are gotten rid of by cutting them before the seed has formed.

Biennial weeds, or those that live for two years, produce roots, stems, and leaves the first year. The second year they produce blossoms and seeds. If they are mown before they have formed seed, they also will be destroyed. Cultivation in the fall will kill them.

Perennial weeds, or those that live for more than two years, are not so easily controlled. If they are prevented from forming seeds, they still will grow from the roots. Each fall they die down to the ground, but in the spring send up new plants from the roots. The only way to get rid of them is to dig them up or to crowd them out by keeping the land tilled or occupied by other plants.

FIG. 103. — Canada thistle is one of the worst weeds on the farm.

Ridding the farm of weeds. — The best method of getting rid of weeds on the farm is by good farming. The man who has a well-planned crop rotation system, tills his crops at the right times, cuts the weeds in the fence-rows and other waste places, and keeps his land so much occupied with growing crops that there is neither time nor room for weeds to grow, will have little trouble.

Weeds are most easily destroyed when they are young. If they are not disturbed until after they have become well rooted, they cannot be removed by cultivation. They must then either be dug out with a hoe or pulled by hand. The farmer who runs a weeder or harrow lightly over his corn or potato field, just before or soon after the plants are up, will kill most of the weeds.

To keep the land free from weeds the farmer must not sow them himself. Unfortunately, much of the seed of farm crops, especi-

ally of grasses, which is sold on the market is not clean and pure: that is, it contains large numbers of weed seeds. Frequently there are thousands of weed seeds of many kinds mixed with every quart of timothy or clover seed that is sold. The use of such unclean seed is one of the most common means of establishing weeds on the farm. If the farmer does not know that his seed is free from weeds, he should either examine it himself or send it to the agricultural experiment station in the state. Prevention is better than cure.

Lists of Weeds. — It is impossible here to name all the kinds of weeds; but a small list, classified by length of life, may serve as a framework to which the pupil may add others that he knows:

Annual Weeds

Purslane, or "pussly"	Barnyard-grass
Pigweeds, of several kinds	Crab-grass
Smartweeds	Squirrel-tailgrass
Mustard	Chess
Ragweed	Chickweed
Clotbur or Cocklebur	Dodder
Jimson weed	Cockle
False flax	Mayweed
Buffalo bur	Prickly lettuce (sometimes biennial)
Kinghead	Shepherd's Purse
Russian thistle	Tarweed
Pepper-grass	Tumbleweed

Biennial Weeds

Wild Carrot	Wild parsnip
Mullein	Sweet clover
Burdock	Brown-eyed Susan
Bull or pasture thistle	

Perennial Weeds

Quack-grass	Golden rod
Johnson-grass	Sorrel
Hawkweed	Buttercup
Dandelion	Yarrow
Poison ivy	Bindweed
Sow-thistle	Live-forever
Docks	Man-root or Man-vine
Canada thistle	Coco-grass, or Nut-grass
White daisy	May-pop
Plantains	Sneezeweed

Problem 160. Count the number of seeds on a ripe dandelion head. Also count the number of seed stalks which one plant will produce. If the plant produces five seed heads, or balls, in one year, and each head contains two hundred seeds, how many plants could be produced in five years from one plant? How many do you suppose could be produced in one year from all the dandelions in your neighborhood if they could find a place to grow?

Problem 161. Name four of the common weeds in your locality, and tell where they grow and how they spread. Can you name one annual, one biennial, and one perennial?

Problem 162. How may weeds be kept out of the meadow?

Problem 163. What weeds are most common in the cornfield? In the wheatfield? the meadow? the pasture?

Problem 164. Do the best farmers in your neighborhood have many or few weeds in their fields? Do those that have few weeds practice crop rotation? Can we judge of the success of a man by the weeds on his farm?

CHAPTER XXIX

INSECT ENEMIES OF PLANTS

Plants are not free to live their lives undisturbed. Not only must they struggle for room, light, moisture, and plant-food, but they are constantly besieged by an innumerable army of enemies. Weeds try to crowd out and take away their food-supply. Insects come upon them to eat them up or sap their life blood. Diseases come to weaken and destroy whatever they lay hold on.

Of these enemies, none brings greater devastation to the farmer's plants than insects. In a single year, they destroy $700,000,000 worth of crops in the United States alone. This is more than all the money spent by our national government. It is an enormous sum to pay for the support of this destructive army. How to protect his crops and reduce this expense, is one of the greatest problems the farmer has to face.

There are many kinds of insects. — Nearly every kind of farm plant has at least one insect enemy. There are enemies of vegetable crops, others of grain crops, fruit crops, forest or wood crops, and all the list of farm plants.

Some crops have very many insect enemies, each of which causes injuries in its own way. The apple is one of these. The small brown bud-moth devours the tender leaves and flowers of the opening buds in early spring. It is assisted by the case-bearers and the tent-caterpillars. Later the leaves may be attacked by canker-worms and leaf blister-mites. The fruit may be visited by the codling-moth and the apple-maggot, which bore their tunnels through it and make the apples "wormy." The San José scale, oyster-shell scale, and scurfy scale, live on the trunk and

branches, sapping out the juices. The San José scale also fastens itself on the fruit. Into the trunk the round-headed borer eats his way and adds to the destruction.

Fortunately for the apple grower, not all of these enemies are likely to fall upon his trees in the same year, at least not in dangerous numbers. But some of them will always be present to weaken his trees and reduce his crop unless he is able to prevent them.

The fruit-grower is troubled most by the insects just named for the apple, also with the aphis, curculio, leaf-hopper, flea-beetle, and pear psylla.

FIG. 104. — A tree almost stripped of its leaves by caterpillars, which are biting or chewing insects.

The more common insect enemies which the grain farmer has to fight are the cutworm, root-worm, chinch-bug, grasshopper, hessian fly, and army-worm.

The vegetable-grower has to contend with the potato beetle, cabbage-worm, cabbage aphis, striped cucumber beetle, plant-lice, flea-beetle, and white grubs.

Nature helps the farmer. — The farmer is not alone in his fight against insect pests. Nature lends him aid that accomplishes more than anything he can do. Strong winds, sudden changes of temperature in winter, rains, and forest and prairie fires destroy vast numbers of insects. Many birds feed largely on insects, and numbers too great to be counted are destroyed by them every year. Birds are really among the farmer's best friends.

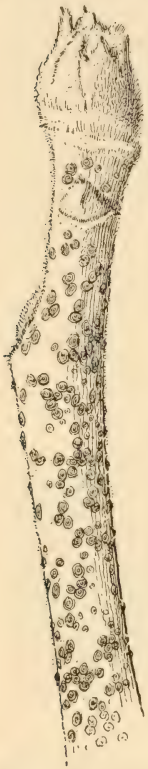

Fig. 105. — Example of a sucking insect. San José scales (enlarged) attached to a twig and drawing the juices from it.

But, strangely enough, the insect enemies of the farmer find their greatest foes among their own kind. Some insects prey upon others. A little lady-bird beetle saved the citrous orchards in California by destroying a scale insect that was ruining them. It would not be possible to grow wheat in many parts of the United States if it were not for little insect friends of the farmer that prey upon the hessian fly.

The farmer's methods. — Man cannot depend on Nature to defend his crops, but must enter the conflict himself. For centuries he has been fighting insects. The ancient Greeks mixed hellebore with milk to kill flies. The Romans required the inhabitants in regions that were overrun with grasshoppers to kill certain quantities of them. In the Middle Ages, priests marched around fields that were infested, praying and pronouncing curses on the pests; or the insects were summoned to appear in court and told to leave the country.

The farmer of to-day is beset by so many pests that he has to use more active means than these. His present methods of defense are of three general kinds: (1) hand, or mechanical methods; (2) farm practices; (3) spraying with poisons.

(1) *Hand, or mechanical, methods.* — Insects are gathered and destroyed by very many different kinds of hand methods. Sometimes they are merely picked by hand, as potato beetles in the garden patch. Sticky pans may be drawn across fields to collect grasshoppers, or held near grape vines and the leaf-hoppers jarred into them. Sticky bands placed about trees will catch large numbers of canker-worm moths as they crawl up the trunks. Sheets may be placed under small plum trees and the trees jarred so that the curculio insects will fall into them. Strips of tar poured along small ridges plowed up all about a field will prevent chinchbugs from passing.

FIG. 106. — The moths of canker-worms stopped by sticky band in their progress up a tree.

Many other hand, or mechanical, methods are employed. They are most useful in small areas or gardens.

(2) *Farm practices.* — We have learned that crop rotation helps to destroy weeds. It also helps to destroy insects which attack such crops as corn, clover, wheat, and potatoes. When the insects find their favorite crop gone and replaced by one they do not like, they are without food and starve to death.

Good tillage destroys many insects and grubs that live in the soil, such as wire worms and white grubs. Canker-worms, which attack fruit trees, live in the soil part of the time during their development, and are easily killed by tillage.

Sometimes crops can be planted early enough so that they will be able to resist the attacks of insects when they come. Or strips of the crop may be sown around or near the field to attract the

attention of the on-coming pests. Such strips are called "trap crops" because they are planted to entrap, or catch, the insects. While the insects are working on the strips, the farmer destroys them.

One of the best methods of protecting crops from their enemies is to keep the farm clean; that is, to burn up all weeds, rubbish, cabbage stumps, old vines, tree prunings, and the like, so that the insects will have fewer places in which to live over winter.

(3) *Spraying with poisons.* — Farmers have found that one of the best methods of protecting their crops is to spray them with poisons that will kill the pests. In order to spray successfully, they must know something about the insect they desire to kill.

Fig. 107. — A large spraying outfit operated by hand power. For use in orchards.

Insects secure their food in one of two ways. Some of them, as caterpillars and potato beetles, are provided with strong jaws which enable them to bite off and swallow solid pieces or particles of their food-plant. They are called *biting* insects. Others, as plant-lice, scale insects, and mosquitoes, do not have jaws for biting and chewing, but are provided instead with long, tube-like mouth parts. These they force into the tissues of their food-plants, and suck their food. They are called *sucking insects.*

Biting insects can be killed by covering the leaves of the plants they attack with poison. When they chew the leaves, they get the poison and die. Sucking insects, which secure all their food from inside of the plant tissues, are not disturbed by any poison that is

on the surface. In order to destroy them, it is necessary to spray at such a time that the poison will be placed directly on the bodies of the insects themselves. When they are "hit" by the poison spray, they are killed.

FIG. 108. — Sugar-beets attacked by the potato scab disease. The fungus of this disease lives in the ground from year to year and may injure other vegetables beside potatoes.

The kinds of poisons to use. — Most of the biting insects are killed by poisons that contain arsenic. Such poisons are sold under the names arsenite of soda, arsenite of lime, and arsenate of lead. Some other kinds that do not contain arsenic, as Paris green and hellebore, will also destroy biting insects.

Sucking insects are killed by poisonous powders, oils, soaps, and other special mixtures. The best known powder is the ordinary insect powder. Substances known as whale-oil soap, fish-oil soap, kerosene emulsion, and lime-sulfur wash are commonly used against the sucking insects.

Spraying. — Poisons used for spraying, except some that are powders, are applied in a liquid form. Usually the poison is dissolved in water. The spray mixture, as it is then called, is placed in a tank, from which it is forced by a pump through a hose having a nozzle at the far end. This nozzle breaks the mixture into a fine spray or mist. By having the spray fine, the foliage of the plant or tree is covered more thoroughly and with less quantity of the mixture.

The farmer needs to know when to spray his crops, and which kind of spray to use in order to protect his plants from particular insects.

Problem 165. Name three insects that the farmer must fight against, and tell what each attacks.

Problem 166. Describe the different methods of destroying insects that are used by the farmers in your locality.

Problem 167. Can you tell what insects breed in low, wet places?

Problem 168. If any of the farmers in your locality spray, for what insects do they spray? What poisons do they use? What crops do they spray?

Problem 169. Have any crops on your father's farm, or a neighbor's farm, ever been entirely ruined by insects? When? By what insects? How much did the loss of the crop cost the farmer?

CHAPTER XXX

DISEASES OF PLANTS

PLANTS, like animals, have diseases that disable or kill them. Almost every plant that is cultivated, be it vegetable, grass, grain, fruit or forest tree, has one or more diseases to which it is subject. There are diseases of the roots, others of the stem, others of the leaves and fruits. Sometimes the entire plant is weakened or destroyed, and at other times only the part that is diseased.

FIG. 109.— Corn attacked by the smut disease.

The nature of plant diseases. — Most of the diseases of plants are caused by fungi. These, as we have already learned, are plants of a low order. Many of them live either wholly within other plants or on their surfaces. In the latter case, they send their thread-like roots in search of food into the tissues of the plant. Because they live wholly at the expense of others, they

are called *parasites*. The plants on which they live are spoken of as their hosts.

The fungi are very different from other plants. They bear no flowers, and consequently never produce seeds like those of flowering plants. They do produce little bodies called spores, which answer the same purpose as seeds. The cloud of dust or smoky powder that rises from the puffball that we kick as we walk through the cow pasture is composed of spores. The puffball is a fungus, and its smoke consists of millions of spores from which other puffballs may grow.

The fungi which cause disease in plants are parasites. They live on or within the tissues of other plants, and in exchange for their food-supply, or rather in securing it, produce disease in their hosts.

We have all seen rotten apples, or peaches, or oranges. These fruits are diseased. Fruit rot is a disease. So also is scab on potatoes, smut in wheat, oats, or corn, blight of pears and apples, club-root of cabbage, curl of peach leaves, and wilt of cotton.

How plant diseases spread. — The light spores of fungi are carried by wind, water, and insects from one place to another. They alight on the surfaces of plants, or in wounds, cracks, and crevices. If they find suitable conditions of food and moisture, they will begin to grow, working their way into the plant tissues from the outside.

Some diseases live in the soil and attack the roots. Plants that are grown on such soils become diseased if they are subject to the kind of disease that is present. When taken to other places such plants carry the disease with them, and the soil in the new field becomes infected. Tools that are used in these soils carry the disease.

The fruit-grower may spread disease by means of his tools also. When he cuts away a diseased branch with a knife or saw, the spores may be left on the blade. Then, when he cuts

away a healthy branch, the disease may be deposited on the fresh surface left by the saw.

Plant diseases are frequently spread by spores on the seeds of crops. We have seen the black or smutty heads of wheat and oats as they stand in the field. These black heads are diseased, and are filled with spores. When the grain is threshed, the cloud of black dust that rises as it passes through the thresher consists of these spores. The dust settles on the grain as it comes from the machine. When any of this grain is planted, the disease is present to develop in the growing plant.

The fact that many plant diseases are contagious, or "catching," is well shown in the apple and potato bins. One rotten apple or potato may in time spread decay to all the others in the bin.

Diseases must be prevented. — Since the fungi that cause plant diseases draw their food from within the tissues of their hosts, they are not greatly disturbed by any poison placed on the surface of the plant after they have become established. They must be prevented, for they seldom can be cured. Several means of prevention are in use, about some of which we shall now learn.

Rubbish should be burned. — Every diseased leaf, branch, fruit, or vine bears millions of spores, a single one of which can convey the disease to a new plant. These parts should be gathered and burned. The diseased limbs that are cut from fruit trees should not be allowed to lie in the orchard, but should be burned at once. The stumps of cabbages that have been attacked by club-root should be raked together and destroyed by burning. Keeping the farm clean of all such rubbish is the farmer's first step in protecting his crops.

Clean, vigorous seed should be used. — The second step is to plant seed that is both clean and vigorous. Strong plants that are grown from vigorous seeds are as much more likely to resist disease as are strong boys and girls.

Seed that has already been infected with spores may be made clean by certain kinds of treatment or disinfection. Before it is

planted, it may be dipped into a chemical solution that will kill the spores. The solution most commonly used is known as formalin, or formaldehyde. Some diseases will be destroyed by

FIG. 110. — Potatoes that were not sprayed and have been destroyed by the potato-blight disease.

suspending the seed, inclosed in a sack, for a few minutes in a tub of hot water.

This method of prevention is used for crops that are grown from seeds, and that are difficult to spray in the field. The seeds of grains, millet, flax, onions, and potatoes are often so treated.

Spraying is the most common method. — If all of the surfaces of a plant are covered with a thin film of poison before the spores arrive, they will offer a very unsafe home for the spores. Destruc-

tion will be in store for them wherever they alight. The poison may be in the form of powder and be dusted on. More commonly, however, it is a liquid, and has been sprayed on in much the same way as is done for insects. If the spray is applied after the spores

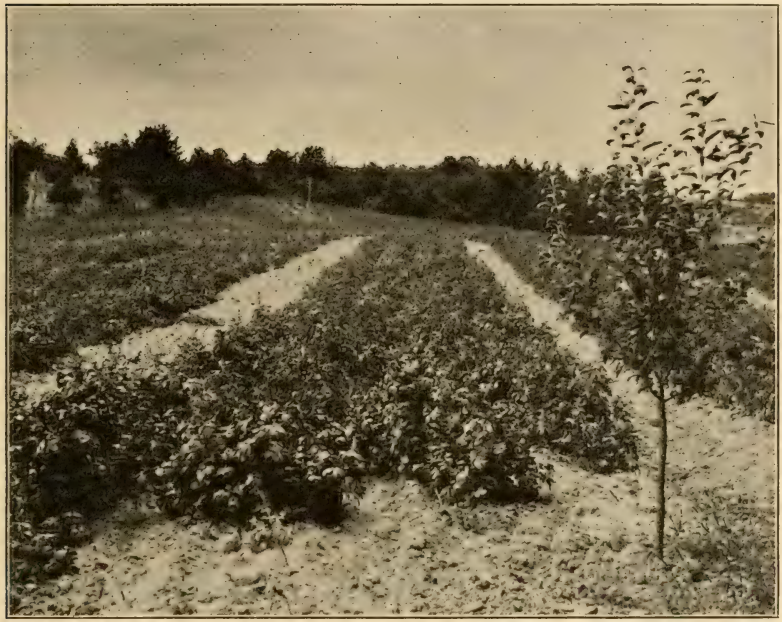

FIG. 111. — Potatoes sprayed as a protection against blight. Does it pay to spray?

arrive, it will keep them from spreading to other parts of the plant, or to other plants.

A long list would be necessary to name all the diseases for which spraying is the common remedy. We may name a few of them: apple scab, leaf-spot, asparagus rust, onion mildew, celery blight, cucumber blight, black rot of grapes, lemon scab, lettuce leaf-rot, orange scab, peach scab, peach leaf-curl, pear scab, potato blight, and potato rot.

A spray mixture that is used to destroy the spores of plant diseases is called a *fungicide*. The word means a substance that will kill fungi. The fungicide used more than all others is Bordeaux mixture. It consists of lime and another chemical called copper sulfate or blue vitriol, dissolved in water. Another common fungicide is lime-sulfur. It is a mixture of lime and sulfur mixed in certain proportions in water.

Other methods of prevention. — Fruit trees are attacked by many kinds of diseases. When large limbs have been pruned off, spores may settle on the fresh wounds and cause decay to appear. If the cut surface is coated with paint, tar, wax, or some other substance, the spores may be prevented from entering. Farmers who do not take this precaution often lose valuable trees.

Rotation of crops will lessen injury from those diseases that live in the soil. Usually such diseases will attack the roots of only one or two kinds of plants. If these plants are not grown on the land for a few years, the spores in the ground will die.

A farmer will sometimes find that one variety of wheat or potatoes or cotton will not be greatly injured by disease, while another variety on his farm, or a neighbor's, will suffer very much. He discovers that some varieties of plants are able to resist disease much more successfully than others. By planting each year the seed from the variety that is injured the least he may greatly reduce his losses. Some persons are now spending much time trying to develop varieties of crops that can wholly resist the attacks of disease.

Problem 170. Collect and bring to school as many different diseased plants or parts as you can find — potatoes, grains, fruits, trees, etc. Note what part of the plant is attacked in each case. Find the spores.

Problem 171. Dip a match in the mold on a rotting apple, or other fruit, and draw it across a slice of moistened bread. Set the bread in a damp place for a few days and watch it. How did the mold which appears come to be there? Did you plant the spores? Where does the mold get its nourishment?

Problem 172. Name the diseases which injure crops in your locality. If you do not know, ask your father.

Problem 173. Find out, and explain to the class, what methods are used in your locality to prevent diseases from spreading.

Problem 174. Give as many reasons as you can why a farmer should not allow weeds, limbs, roots, and other kinds of rubbish to lie scattered over his farm.

CHAPTER XXXI

THE IMPROVEMENT OF PLANTS

Man is able to modify, or change, plants. The ancestors of all our cultivated plants lived originally in a wild state, but in many cases were quite unlike our present forms. The changes made by man have been in the nature of improvements, so that the cultivated plants might better serve his needs. The large, juicy garden strawberry is greatly improved over its wild ancestor. So also is the large garden blackberry over its small wild form found in neglected fields.

How the improvement has come about. — In wild conditions, all plants struggle for a place to live, and for food and moisture. Frequently they appear in places where they cannot do their best and must adapt themselves to the unfavorable conditions about them.

Cultivated plants are spared much of this struggle. Instead of being planted in a tangle, each crop is by itself and each plant among its own kind, the individual plants are placed where they can grow best and with least interference from others. Competing plants (weeds) are kept away. The soil is specially prepared for them, and if it is lacking in fertility, plant-food is added. Moisture may be added directly, or saved for the plants by a surface mulch. The farmer reduces the struggle for existence among his crops so far as possible, and tries to make the conditions for growth perfect. All of these advantages, which constantly stimulate plants to do their best, have gradually modified the cultivated forms from their ancestors. In some cases the changes have been great, in others not so great.

There is another reason why plants have improved in cultivation.

No two plants, or parts of plants, are exactly alike. If we compare any two plants of the same kind ever so closely, we shall find that they differ from each other. The difference may be in size, form, color, mode of branching, number of leaves, number of flowers or fruits, vigor, season of ripening, or other factors.

FIG. 112. — The improvement brought about by domestication. Wild blackberries on the left, garden blackberries on the right.

From the beginning man has taken advantages of these differences. The plants which showed some quality or characteristic which made them more useful to him were chosen for the new crop. This long-continued choice of the best has been the means of much improvement in plants.

The differences have great value. — The differences among plants of the same kind are spoken of as "variations"; that is,

the plants vary or differ from one another. The fact that plants vary is of great importance in all efforts to improve them. If they

FIG. 113. — No two plants are alike. These corn plants are all of the same variety, but show great differences in the position of the ears. There is room for improvement.

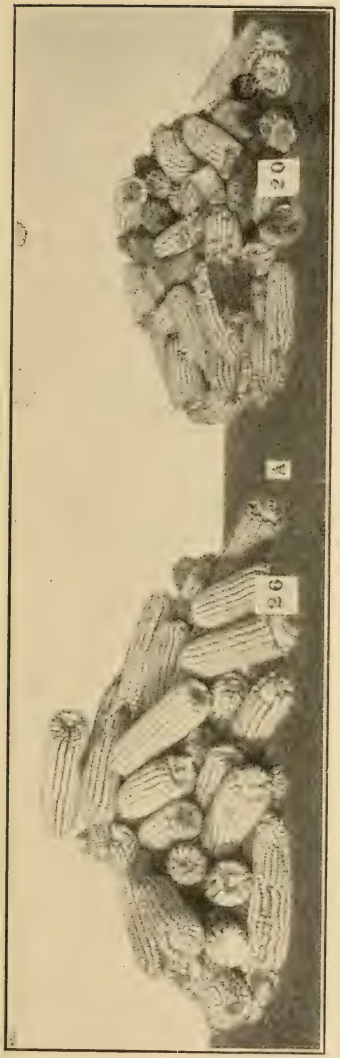

FIG. 114.—One step in plant improvement. The two piles of corn were grown from the seed from two ears of the same variety of corn. The rows from which the ears were taken were of equal length. Does it pay to select the ears for planting? From which pile should next year's crop be grown? The best ear and the poorest ear in the pile at the left may give crops next year that are as different as these two piles; but both piles should be larger.

did not vary, but held steadfastly to a particular form or type, they could not be changed or improved. It is because plants do vary that the farmer is able to select some from the others, and so to improve his crops.

Means of improvement. —Two methods of improving plants are in use. One is gradually to modify the forms that now exist, so as to establish, or "fix," them and to make them more useful. The other is to create new kinds that will be better than the types now raised.

Improving present types. —Let us suppose that the farmer wishes to improve his corn crop. He must first have in mind what he wants to accomplish — to develop longer ears or heavier ears, more ears to the plant, earlier maturity, or some other quality. With his ideal in mind, he will go over his cornfield while the corn is growing and select the plants that most nearly resemble the

ideal. He will mark them so as to harvest them separately and save the seed.

The next year, the seed of his chosen plants will be sown by itself, away from any other cornfield, so that the new crop may not be mixed with any other variety. This field will be gone over before harvest, as in the first year, in order to select the plants in it that are nearest the ideal. Some of them will be nearer than in the first year.

From the second year's crop, grown from the seed selected during the first year, only that seed will be saved which comes from the best plants, those that are nearest to the type that is wanted. Year after year this selection and planting of the best will go on until the farmer has developed the type that he desired; that is, until he has improved his crop up to his ideal.

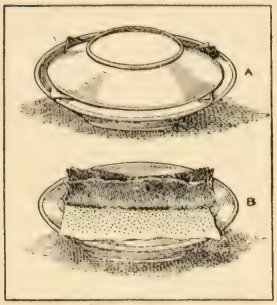

FIG. 115. — A simple home-made seed-tester. Two plates and two pieces of canton flannel. Blotting paper will serve as well as flannel.

This method of improving crops is called "selection." It should be used by every farmer. The one who always chooses his best for his next year's seeding will grow better crops each year.

Creating new types. — Let us suppose that in our locality two varieties of corn are grown. One produces larger ears than the other, but the second one matures earlier than the first. The farmer may wish to have a variety that will have large ears and also will mature early. He desires to combine in one plant the best qualities of the two. How shall he do it?

We know that if the kernels of corn are to be developed, pollen from the tassels must fall on the silks, which are part of the pistils of the corn plant. When the pollen from one plant falls on the pistils of the same plant, the same sort or variety of corn will be produced. If the pollen from a different plant falls on the silks, the kernels of

corn will combine the qualities of both plants, or parents, in some measure, and the offspring will show some of these qualities.

If the farmer places the pollen from the variety of corn that matures early on the silks of the variety that has large ears, the characters of both plants will probably be represented in the seed that is formed. When this seed is planted the first year, it may show some of the qualities of both parents. Most likely it will resemble one parent much more closely than the other.

This seed is planted for the second year's crop. When the time comes for the silks to receive pollen, the tassels will be cut off, or covered, so that none of the pollen of the same plant can fall on the silks. Pollen from the other parent, the one that appears least in the new plant, must be placed on the silks. The plants from the seed that results from this second crossing should approach the ideal type somewhat more closely than that from the first year. This operation will be continued year after year, until the desired type is secured.

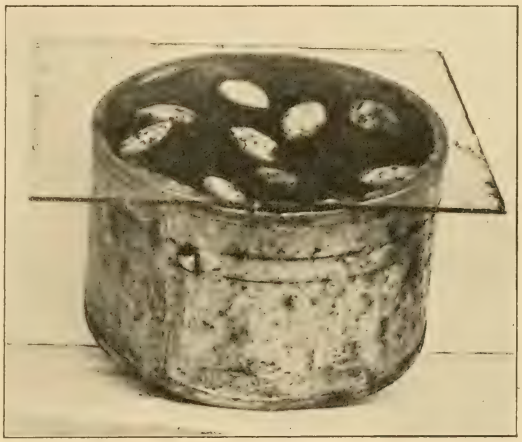

FIG. 116. — Another simple home-made tester.

When two varieties are mixed in this way, they are said to be "crossed." Crossing is the most important means of plant improvement.

Plant-breeding. — The changing of plants by man for the purpose of producing certain desired results is "plant-breeding." Every farmer should be a plant-breeder to the extent of improving

his varieties by means of selection; but it is from professional plant-breeders that we are to expect most of the new varieties and new types.

Problem 175. If there are wild strawberries, raspberries, blackberries, or apples in your locality, compare them with the kinds that are cultivated. Explain what the differences are.

Problem 176. Compare two plants of any kind of crop grown on your farm. Tell in what respects they differ from each other. Can you find any two that are exactly alike?

Problem 177. Find out whether any farmers in your locality are trying to improve their crops either by selection or by crossing. Ask them to explain just what they are doing.

Problem 178. Ask your father for a small piece of land, on which to begin an experiment to improve the crop that is raised most largely on your farm. If yours is a fruit farm, plant potatoes or corn or small grain. Each year select your best seed for the next year's crop, and ask your father to plant all of the other seed from your plot by itself in his field crop. Notice from year to year whether better crops are secured from your seed than from your father's.

Problem 179. Seed testing. One of the means of improving plants is to plant only seed that is strong and vigorous, and will make a healthy growth. Much of the seed on the market is poor, and some of it either will not grow when planted or will make only a weak growth. In order to know whether your seed is strong and healthy, it should be tested.

For this purpose, the seed should be germinated or sprouted. The simplest device in which to germinate the seed consists of a pie pan covered with a square pane of glass or by another pan. This device is suitable only for small seeds, as the clovers, grasses, and flower seeds. One hundred seeds are placed on a piece of clean blotting paper which has been moistened with water. Another moist blotter is placed over this. The cover should fit tightly over the pan in order that none of the water may escape. If the blotters should become dry in a few days, a very small amount of water should be applied. When the sprouts on most of the seeds are one-fourth to one inch long, the ones which have germinated should be counted. This will give the percentage of germination. If the test shows a low percentage of live seeds, the seeds should be discarded or a larger amount sown on a given area. From 90 per cent to 95 per cent germination is considered good for most seeds.

For testing corn, beans, melons, and other seeds of equal size, take a box

of any convenient size, about four inches deep. Fill it one-half full of sawdust which has been moistened thoroughly. Over this tack a piece of cheese cloth marked off in squares. For testing ears of corn, these squares should be numbered. The numbers should correspond with numbers attached to the ears of corn. The numbered ears of corn should be arranged consecutively and placed where they will not be disturbed until the test is finished. Take up ear No. 1. Remove two kernels of corn from near the tip; turn the ear one-third around and remove two more kernels from the center. Now turn it around another third of the distance and remove two kernels from near the butt. Place these kernels on the square numbered 1 on the cloth. Continue this operation until all the ears are represented in the germinator, one in each square. Place another piece of thin muslin over the grains of corn, allowing it to extend up the sides of the box for some distance. Fill a sack, made to fit snugly in the box, with damp sawdust. Press this down tightly over the corn and set the box where there will be no danger of freezing or disturbance. In mild weather the corn will germinate within a week. Some will probably germinate 100 per cent, while others will be less than this. The sprouts on some will be weak, while those on others will be strong. It is safe to take these typical kernels as an index of what the whole ear would do if planted. Therefore, if the test is unsatisfactory in respect to any ear, this ear should be discarded at planting time.

If shelled corn or other loose seeds are tested in this germinator, one hundred seeds should be used, as in the case of the pie tin. At least 85 per cent should germinate strongly or the seed should be rejected.

PART IV

FARM ANIMALS

CHAPTER XXXII

THE NEEDS OF FARM ANIMALS

Farm animals are kept for what they can add to the farmer's comfort, pleasure, and income. We may call them productive agents because they must return certain products to their owner. The products which they return will vary with the different classes of animals. Horses return labor; cattle return milk, hides, meat, and sometimes labor; sheep yield wool and meat; swine return lard and pork; poultry return eggs, meat, and feathers.

In order that animals may be productive, they must receive such care and attention as will keep them in the best condition for work. If this care is not given, they still may live; but they are not likely to return a profit to their owner. Attention must be given to their food, air, shelter, rest, and exercise, which are their more important requirements for existence and service.

Food requirements. — We may liken an animal to a machine, which, in the performance of its work, receives wear and tear in its various parts. As coal is shoveled in at the furnace door to make the energy to turn the great wheels of the machine, so must food be taken into the body to supply energy and replace waste that results from using the body. The food requirements of farm stock demand more attention from the owner than any of the other needs.

We readily understand that a horse at hard work must have an abundance of the right kinds of food to keep his body in good condition. Perhaps we have not realized that in a similar way it is a tax on a cow to give a large flow of milk. It is likewise a tax on sheep to produce wool, and on hens to lay eggs. To produce

wool and eggs is a form of effort or work; and it uses up energy. Abundant food is as necessary in one case as in another.

Foods are given for two purposes: to maintain or support the animal, and to lay up an extra or reserve supply for the work the animal has to do. All profit comes from the reserve supply, that which the animal may use for work. The maintenance ration [1] alone merely keeps the animal alive. To realize a profit on animals, there must be food for growth and reproduction, as well as service, in addition to mere sustenance. When stock, as beef cattle, swine, and some kinds of poultry, are reared for meat, the reserve supply enables them to fatten rapidly, so as to be ready for market in the shortest possible time. In the draft animal, the reserve supply keeps the muscles in repair and provides the energy for action. In the cow, the reserve supply produces milk; in the sheep, it produces wool as well as mutton.

To satisfy the animal's needs, the maintenance ration must provide the materials out of which the body is created and by which it may be sustained. If we study the composition of the animal body we shall find these materials to be mineral matter, nitrogenous matter (containing nitrogen), and fat.

Water. — There is much water in all parts of the body. Often one half of the body is water. It becomes part of all bone and flesh. It is used to carry, or transport, the building material, just as it is in plants. The blood is largely water. Water also helps to remove the waste or worn-out parts from the body. Animals require at all times an abundant supply of good drinking water.

The mineral matter in the body is found chiefly in the bones. From 2 to 5 per cent of the body is mineral, which is supplied to animals in their food. It comes from the mineral parts of plants, and is supplied to plants by the soil.

Nitrogenous matter is the name given to substances containing nitrogen. Flesh, skin, muscle, hair, wool, horn, hoof, feathers,

[1] The quantity, or portion, of food that is given to an animal in one day, is spoken of as a *ration*.

blood, lean meat, white of egg, and curd of milk are rich in nitrogen.

We know that all green plants require nitrogen in their growth. Some of this nitrogen is found in every part of the plant, in the roots, leaves, stalks, and fruits or grains. When the plants or grains are fed to stock they provide the required nitrogenous matter.

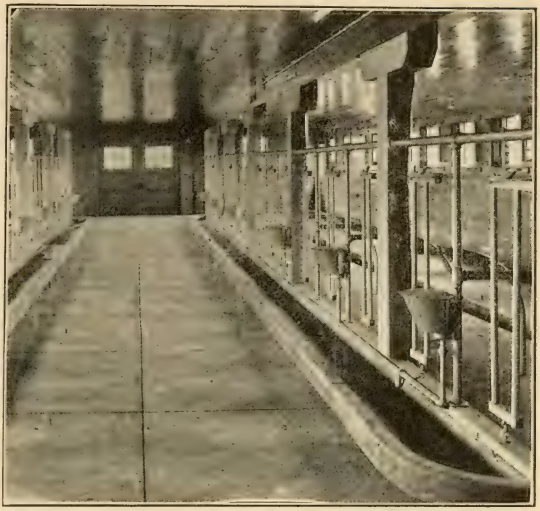

FIG. 117. — Animals require drinking water. It may be kept before them at all times in individual troughs or pans.

Fat is reserve food, or that laid by for special or later use. The amount of it in the body will vary with the age of the animal, the work it does, and the kinds and amounts of food given. The lean animal seldom contains less than 5 per cent, and the fattest seldom exceeds 30 per cent.

Fat-producing materials are usually given to animals in the form in which they occur in plants; that is, in the form of starches and sugars. The chemist calls these materials carbohydrates, because they are made from carbon and water. Carbohydrates make up the larger part of dried plants, including all kinds of hay and fodder, and are abundant in roots and grains. Within the animal body, the carbohydrates are changed into fat.

Uses of nitrogenous matter and fat. — The nitrogenous parts of plants, which are commonly called protein or proteids, build up the working parts of the body. They may be called muscle-

makers, although they have other uses as well. They enter into many of the products of animals. When cows are kept for milk, sheep for wool, horses for work, and geese for feathers, they should be given foods, or rations, containing considerable nitrogen, as it is required for all of these products. It also enters into the composition of fat in milk and meat. It can perform the same use, or function, as fat, when necessary.

Fat keeps the body warm, and, in part, supplies the energy which enables the muscles to work. All the higher farm animals are warm-blooded. They receive their body heat from their food. That is why most animals consume more food in cold weather than in hot weather. Esquimaux and other people who live in very cold climates subsist almost wholly on fatty meats and oils. They need heat-giving foods to keep them warm.

The nitrogenous, or proteid, matter and the carbohydrates, which may include the fats, are the food elements that the farmer must provide for his stock. He seldom needs to supply mineral matter, as only a small quantity of it is needed and all plants contain it.

Air. — Air is as necessary to the animal as to the plant. All of the activities in the body would cease, and the animal would die, if air were not provided. Energy is supplied by a burning of the tissues in the animal body, just as it is created in the steam engine by the burning of fuel. Neither the fire in the engine nor the burning in the animal body can take place without air. This burning is called "oxidation," because it is brought about by the action of oxygen from the air on the animal tissues. The burning of wood is also oxidation, as oxygen is then acting on the dried plant tissues.

A single cow requires, in twenty-four hours, 3125 cubic feet of air, or as much as would be contained in a box-stall about 18 feet by 17½ feet by 10 feet. Stables are not built to allow this much space for each animal, however, so that fresh air must be provided continually by ventilation. Twice as much air space should be furnished in the horse stable as in the cow stable. One cubic foot

of air space for each pound of live animal kept in the stable is a good proportion. When one half or one fourth this amount is provided, as is often the case, the air must frequently be changed.

Shelter. — Animals, like people, are most useful when they are happy and comfortable. They can then do their best. Good

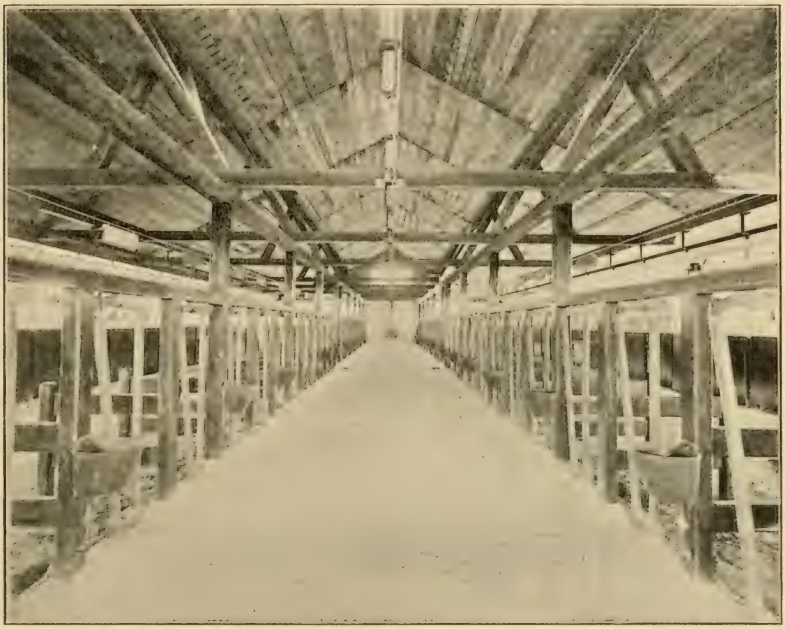

FIG. 118. — A stable that provides room, sunlight, and ventilation.

quarters must be provided for all farm stock. The buildings must afford shelter from storm, protection from excessive heat and cold, proper ventilation, and sufficient sunshine to keep them bright and fresh and dry. Too often the ventilation and the sunshine are not provided for. Under such conditions the animals cannot keep vigorous and healthy, as they should in order to return the largest profit to their owners.

Rest. — Animals need rest periods, and comfortable quarters for resting should be furnished. Rest is as necessary for them as for vigorous boys and girls. There must be time to relax the muscles, to allow all of the vital activities in the body to subside from the increased demands of work, and to repair the broken down tissues.

It has been found that a steer produces 30 to 50 per cent more heat when standing than when lying down. As this heat must

Fig. 119. — Animals need exercise.

come from the burning up of food, there is so much less energy for useful work or fattening. This shows that it pays to provide comfortable quarters and good beds for the farm stock.

Exercise. — Exercise is essential to the healthy development and maintenance of all creatures. It stimulates and strengthens the organs, and this tends to keep the animals vigorous and to prevent disease. Stables should have yards adjoining, which are protected from the cold winds of winter and the hot sun of summer, where the live-stock can be exercised. Ordinarily, the larger the field in which stock may take exercise, the better.

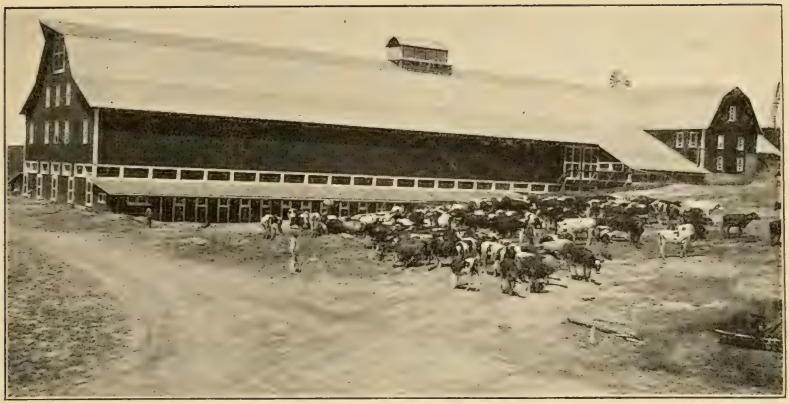

FIG. 120. — A yard adjoining the barn where the cattle may exercise. A Nebraska stock farm.

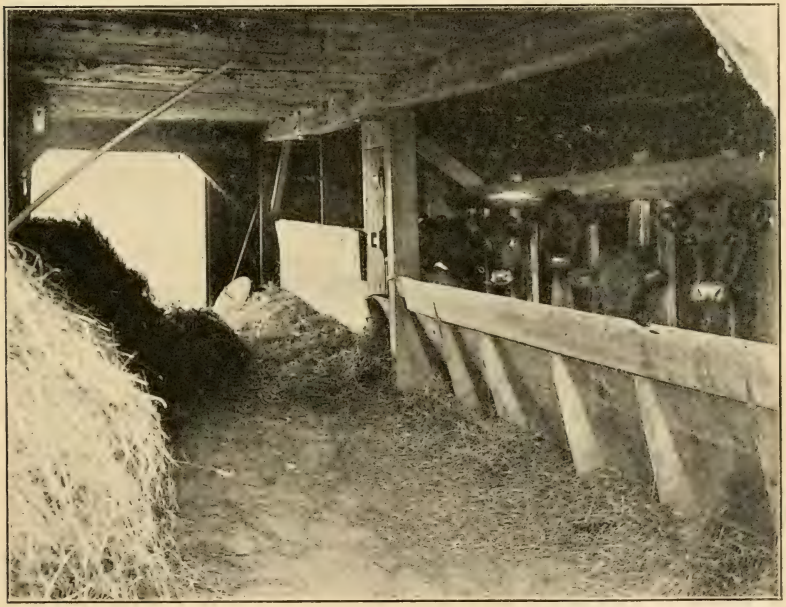

FIG. 121. — Clean milk cannot be produced here. (p 239)

Animals that are being fattened for market should have only sufficient exercise to keep the body in good condition. Exercise requires energy and in fattening animals all the energy possible must be saved for storing as reserve fat.

Fig. 122. — Clean milk is likely to be produced here.

Cleanliness. — Animals require clean food, clean water, and clean quarters, and must themselves be kept clean. Filthy conditions breed disease, and diseased animals are a loss to the farmer. We commonly think of pigs as very uncleanly animals; but if they have opportunity to choose their own beds, they will keep cleaner than they usually are in the pens. Pigs thrive in spite of their filthy surroundings, not because of such surroundings. Nearly all animals are naturally cleanly.

Problem 180. When a horse works hard on a warm day, and "steams" and sweats, what is he wasting from the body? How can this waste be replaced?

Problem 181. When the cow stable is closed in winter, it becomes warm and damp. Why?

Problem 182. Can you make a fire burn in an air-tight can? Why not?

Problem 183. Why does a stout person feel the heat more than a slender person?

Problem 184. If there are animals on your father's farm that are being fattened for market, do they receive different food and care from the others? In what respects?

Problem 185. Name all the different kinds of farm animals in your neighborhood. Tell the purpose for which each is kept.

Problem 186. What care should a working horse receive?

Problem 187. Should animals be given ice-cold water? Why?

CHAPTER XXXIII

THE FEEDING OF FARM ANIMALS

In the preceeding chapter we learned that animals require food both to maintain their bodies in good condition and to repair the tissues that are broken down by work. There must also be food for growth and reproduction. The satisfying of these needs of animals is spoken of as *nutrition.*

We have learned, also, that the food requirements are met by giving animals water and foods containing mineral matter (sometimes called *ash*), nitrogenous matter (or proteids), fats, and carbohydrates. But this is not all. If an animal is to be properly nourished, the foods must be given in certain definite quantities or proportions. This is where skill in feeding and knowledge of the value of various feeding-stuffs is required.

Foods are not all alike. — Feeding-stuffs of many different kinds are given to farm animals. Hays, grains, fodders, and roots are very unlike one another. The farmer who desires to feed his live-stock intelligently must know what these differences are and what effect they have on the animal.

The chemist who has studied the various foods in his laboratory carefully, and has analyzed them, (has taken them apart), tells us that all the ordinary feeds contain water, protein, carbohydrates, fats, and mineral matter, but that most of them contain more of one of these groups than of the others. This is what we should expect, since we know that plants require all of these compounds for their growth. But we do not find the proteids and the carbohydrates in separate packages, so to speak, ready to be mixed as needed. They are combined in all feeding-stuffs and in very dif-

ferent proportions. The chemist discovers what these proportions are. Without knowing this fact, we should not be able to prepare satisfactory combinations of food for animals. With this knowledge, we can learn how to put together the various feeds to give the proportions of each element that are desired. Such a combination of food is called a *ration*.

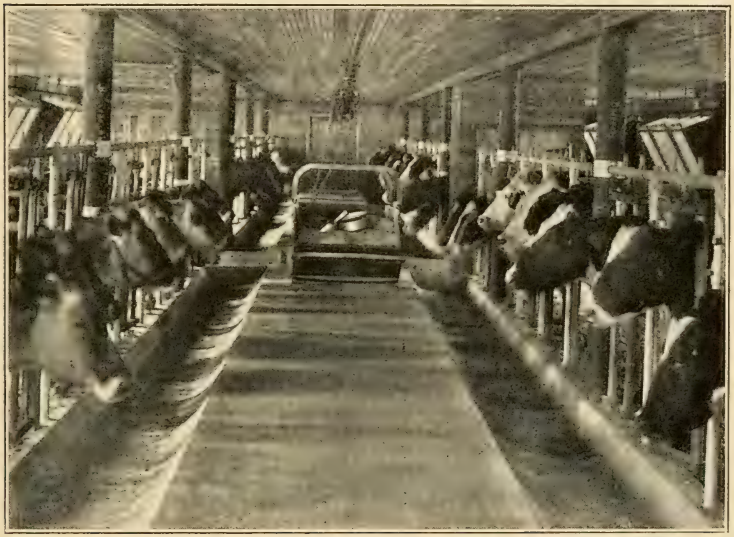

FIG. 123. — The labor of feeding may be lessened by the use of a car, or conveyer for the feed.

Choice of foods. — The choice of foods will vary for different classes of animals and the work they have to do. A horse at work requires different kinds and quantities of food from one at pasture. A cow does not require the same kind of food to produce milk that a hog does to produce pork. Neither does a cow giving milk require the same food as a steer that is being fattened for market.

If we wish to fatten stock for market, we feed fat-producing

foods, — those richer in carbohydrates than in other substances. If we are feeding for work, we give those foods that are rich in muscle-forming materials, the proteids. If feeding for wool, or milk, or eggs, we prepare a ration that contains the proper balance between proteids and carbohydrates to produce the products desired.

Fig. 124. — Another view in the stable shown in Fig. 123. Cattle may be kept clean.

Balanced rations. — Perhaps some of you have heard your father speak of "balanced rations" for his stock. You may know what he means. This is an expression which every farm boy and girl should understand. We may now describe what a balanced ration is.

When an animal is working hard, there is a heavy tax on the muscles and tendons of the body. When it is at rest in the stall, there is no severe strain on the muscles. If the heavy ration that is given to the working animal is given to the idle animal, the latter will not be able to digest and utilize it, and will become sick.

FIG. 125. — Salting the young stock.

The idle animal should be fed a lighter ration. Both rations will contain proteids and carbohydrates, but in different proportions.

When the proteids and carbohydrates are combined in such proportions as experience has shown will produce the best results, we have what we call a balanced ration. The food elements are balanced, sometimes with a larger proportion of one, sometimes

of the other, to satisfy the needs of a particular animal. There is a proper balance for the ration for each animal, which is determined largely by what the animal does. A balanced ration for a horse may not be balanced for a sheep. A ration that is balanced for a cow giving milk would not be balanced if she were being fattened for market.

Experts who have studied the matter carefully have determined approximately how rations should be balanced for all ordinary farm purposes.

Nutritive ratio. — Perhaps some of you have also heard your father speak of the "nutritive ratio" of the feed he is giving his stock. We should learn the meaning of this expression, for it has to do with the most important considerations in the feeding of stock. We do not know whether we are feeding a balanced ration until we know the nutritive ratio.

Let us recall again that the substances or elements in stock-foods that especially concern the farmer, are the proteids and the carbohydrates; and that these two groups of food-elements are used for quite different purposes in the animal body. As they both exist in all food-stuffs in greater or less proportions, the first step in preparing a ration for stock is to determine the proper balance between them for the desired purpose.

These food-elements are "nutrients"; that is, they contain nutriment or nourishment. The nutritive ratio, then, is simply the ratio, or proportion, in which these nutrients (proteids and carbohydrates), are combined in the food. For example, if corn meal is 8 per cent protein and 76 per cent carbohydrates (including fats), these two groups of elements are combined in the proportion of 8 to 76, or, when reduced to its lowest terms, 1 to 9.5. The nutritive ratio, or ratio of the nutrients, of cornmeal is then 1 to 9.5 (usually written 1 : 9.5); that is, cornmeal contains 1 part, or per cent, of protein, to every 9.5 parts of carbohydrates.

Each food has a nutritive ratio of its own. When two or more foods are combined in the ration, which is usually the case, the

complete ration will have a nutritive ratio of its own. This ratio will be different from that of any one of its ingredients. It will be essentially the average of the nutritive ratios of all the foods that compose the ration. In order to get the exact ratio, however, the total composition of all the foods concerned must be considered.

The kinds or classes of foods. — Every boy who has helped his father feed the stock knows that there are many different kinds

FIG. 126. — Salting the sheep.

of foods. Some of them closely resemble others in certain characteristics, so that it is possible to consider them together in groups or classes. Practically all feeding-stuffs may be placed in one of three general classes. These are (1) coarse fodders, or roughage, (2) root crops, (3) grains and meals. Those of the last group are commonly called "concentrated foods" or "concen-

trates," because they contain a large amount of nutriment in a small weight and bulk.

Coarse fodders. — The coarse fodders may contain much carbohydrate, but usually have relatively little protein. They are rough and bulky, and are generally fed to stock in larger quantities than other kinds of feed because they carry considerable material that is of little or no value to the animal. The common

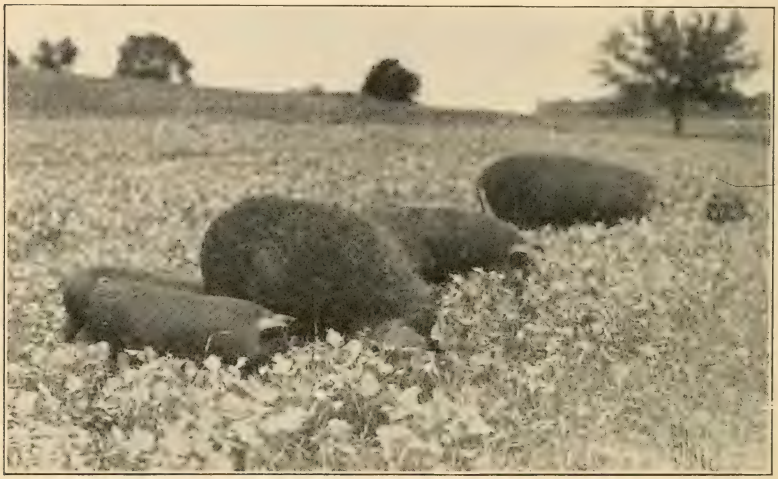

FIG. 127. — Duroc-Jersey hogs at pasture.

coarse fodders are timothy, clover, alfalfa, cowpea hay, and all other kinds of hay, straw, and corn-stalks.

Corn silage is a much used coarse feed. The corn is cut and stored in the silo while it is still green, so that it is juicy and refreshing when fed to the cattle.

Roots and tubers. — Roots and tubers contain a very large proportion of water, sometimes as much as 80 to 95 per cent. Because of this watery or juicy condition, they are said to be succulent.

The more common root crops given to stock are beets, mangels, and carrots. Cabbages, kale, and pumpkins serve much the same purposes as root crops when fed to stock, as they also are watery.

Concentrated foods. — Concentrated foods contain very little water or indigestible matter. They are of two general kinds:

(1) The grains, as, corn, oats, rye, barley, wheat, peas, and beans. These contain a medium amount of proteids and a rather large percentage of carbohydrates. Corn contains a very high percentage of carbohydrate. That is why it is such a good food in cold weather and for fattening animals.

(2) The by-product feeding-stuffs, or those which are left in the manufacture of starch, breakfast foods, flour, sugar, alcoholic liquors, and oils. The common names of some of these by-products are bran, middlings, shorts, rice bran, grits, gluten, cottonseed meal, oil meal, brewer's or distiller's grains, malt sprouts, and beet pulp. For the most part they are very nutritious and easily digested foods. They should constitute some portion of the ration given to all farm animals.

Problem 188. Name the foods that are commonly fed to horses in your locality; to cattle; to sheep; to hogs; to poultry. Tell which are coarse fodders, which roots or succulent feeds, which concentrates.

Problem 189. How many of these different feeds are raised on the farms in the locality? How many are shipped in from distant places? Find out how much the different feeds cost in your neighborhood.

Problem 190. How are these different feeds stored?

Problem 191. If a balanced ration is fed to any of the animals on your father's farm, tell what feeds it includes and why it is balanced; also, what is it fed to accomplish. Ask your father which of the feeds he uses are most fattening.

Problem 192. Why should not the same ration be given to an ox at rest in the stall, as to one that works hard every day?

CHAPTER XXXIV

HORSES

Our ancestors made little progress in the tillage of the soil until beasts of burden were domesticated to do the heavy work. The use of the slow-moving ox was a great advance over hand work. When the horse, which long had enjoyed special distinction as the animal of emperors and persons of noble birth, and of war, was pressed into the common work of the world, rapid progress became possible. The horse had power, speed, and endurance. He worked faster and to better advantage than the ox. The latter gradually had to give place to him.

History. — The history of the horse, through many forms and extending over thousands of years, is one of absorbing interest. Although the modern form of the horse did not exist on the American continent in prehistoric times, yet fossil remains of his very ancient ancestors have been discovered in those parts of the continent which are now included in the states of New Jersey, Nebraska, South Dakota, and Wyoming.

It was many thousands of years ago that Eohippus, the name by which the earliest prehistoric horse was called, lived in the Rocky Mountain range and southward to Mexico. He inhabited also parts of Europe and Great Britain, and could pass between the continents on dry land. This early horse was no larger than a dog. He possessed four toes on each front foot, with the splint of a fifth, and three on each hind foot, with the splint of a fourth. In his day the earth was warm and damp, and the toes added greatly to his ability to move about in the mud.

In time, Eohippus was succeeded by a higher form called Orohippus. This was also a small animal, about fourteen inches high. The splints of the extra toes had disappeared from the feet. This form in turn gave way later to Mesohippus, which somewhat resembled the modern horse. He was about eighteen inches high. In this type the toes had been reduced to three on each foot. The center toe was more prominent than the others and bore most of the weight.

Down through the ages the horse continued, gradually becoming larger and losing the use of his toes. The last stage is the modern horse, with its graceful limbs that terminate in a dense hoof covering the single middle toe. The remaining toes have disappeared, but traces of the two toes are to be found in the splints on both fore and hind legs. The present horse is much larger than any of his prehistoric ancestors.

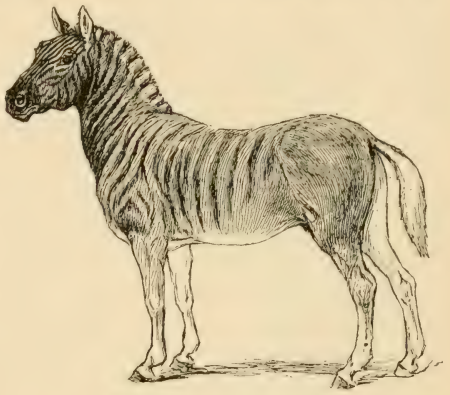

Fig. 128. — The quagga.

The gradual development of the giant draft horse of to-day from the small dog-like animal no larger than the fox terrier is a most interesting demonstration of the changes wrought by nature to adapt animals to the conditions under which they live.

There are three types of horse-like animals in the present day, which mark stages in the development: first, the horse proper, as we know him on the farm; second, the wild ass; third, the zebra and quagga, which somewhat resemble the ass but are beautifully striped. There are still wild horses in herds on the plains of Tartary, and occasional herds of wild mustangs on the

great plains of our own country. The present wild horses of this country, however, are descendents of horses introduced here by Europeans.

The horse was first hunted by man for his flesh for food. Later he was driven, then ridden, and lastly employed as a beast of burden.

Types of domestic horses. — After man had domesticated the horse, he proceeded to develop from him a great variety of races, or breeds, that would be useful to him under particular conditions. By comparing the horses we see on the road, we shall observe that they are of different forms or types. Some possess a form that enables them to draw very heavy loads, but at a slow pace. Some are so formed as to draw light loads and at a very rapid pace. Between these two extremes we may observe a form that is suited to draw a moderate load, but with high action and much style. These are three distinct types, or forms, and they are called draft horses, driving horses, and coach horses.

The draft horse is the largest and heaviest representative of the horse tribe. He is massive, powerful, low-down, blocky, and compact. He has been developed for weight so as to be able to move great loads. In average condition he may weigh from 1500 to 2000 pounds.

There are several breeds[1] of draft horses, a few of which are

[1] The word *breed* is a term applied to a group of animals that rather closely resemble one another, and usually take their name from the region in which they originated. A *variety* is a smaller group within a breed, which includes the animals that still more closely resemble one another. There may be several varieties in one breed. The word *type* is a larger or more general term than breed, and is applied to larger groups composed of breeds and races that have a number of characteristics in common. Thus, we have the draft type of horses, which includes such breeds as the Percheron, Clydesdale, Belgian, etc. We have the meat type of chickens, including the Plymouth Rock, Wyandotte, and other breeds. There are single-comb and rose-comb varieties in the Wyandotte breed, and Barred and White varieties in the Plymouth Rock breed. If we were to represent the divisions by a tree, we should have, first, the trunk, or type, which breaks into smaller branches or breeds; the branches divide into smaller branches and twigs, which may represent the varieties.

popular in America. The *Percheron* breed came from France. It is either gray or black in color. The *Belgian*, usually of a bay color, came from Belgium. The *Shire*, which may vary through bay, brown, and sorrel in color, was imported from England. The *Clydesdale*, from Scotland, resembles the Shire, but may be smaller

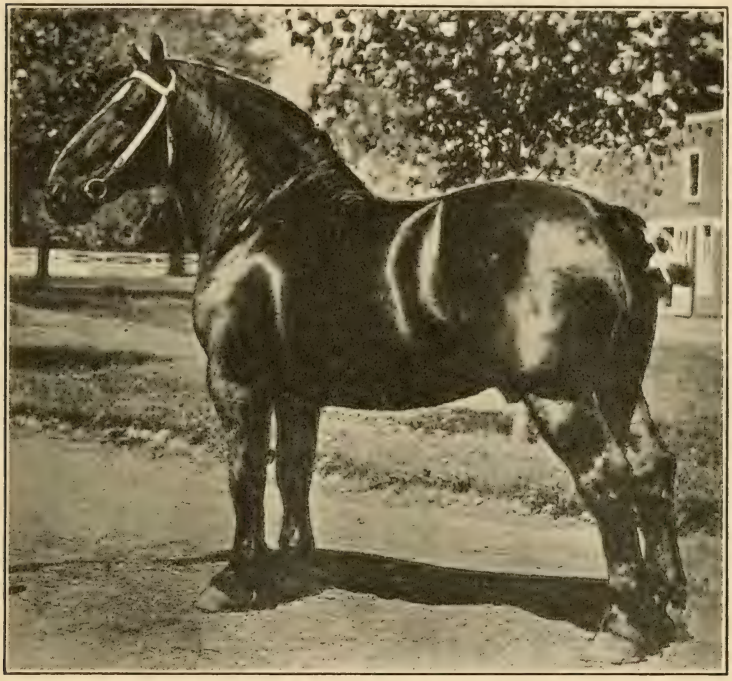

Fig. 129. — Percheron. Draft horse.

and more active. The *Suffolk Punch*, from Suffolk County in the eastern part of England, is uniformly of a chestnut color.

The coach horse is the next largest type. He was originallly developed for pulling heavy coaches at a good speed. He is moderately heavy, smooth and symmetrical in form, and of graceful

carriage. The Hackney, French coach, and German coach are the principal breeds.

The *hackney* came from England, where for centuries he has been a favorite saddler and roadster. His most popular color is chestnut. The *French coach*, as its name implies, was developed

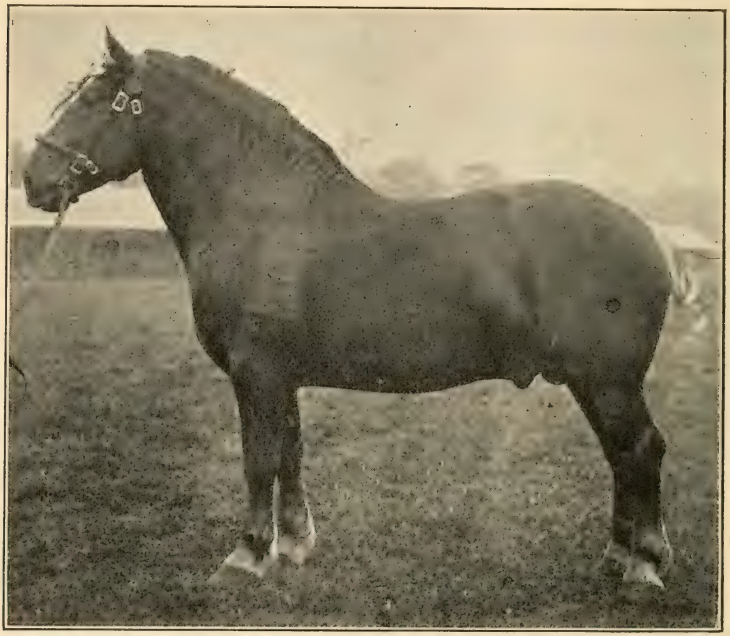

FIG. 130. — Suffolk Punch. Draft horse.

in France and imported to America. Bay and brown are the most common colors in this breed. The *German coach*, bred for centuries in Germany, is usually bay, black, or brown in color.

The American trotter, pacer, or roadster, a distinctly American breed, is the common type of driving horse. It has a rather long, graceful neck, long body, narrow chest, and long legs. The conformation, or general shape, is angular, muscles prominent,

and ribs more or less noticeable. Speed and endurance are important qualities. The colors vary greatly, bay, black, brown, and roan being common.

The American saddle horse, also called the Kentucky saddle horse, is the most beautiful modern breed. He has been developed in America, as his name suggests.

FIG. 131. — Coach horses.

FIG. 132. — Hackney. Coach horse.

He has graceful form, erect carriage, smooth action, and is possessed of much courage and spirit. He may be trained to go several gaits, as the rack, or single-foot, running walk, straight walk, trot, and canter.

Fig. 133. — Arabian horse, Shahwan. Bred in Egypt, and owned in England and then in America. Saddle and driving horse.

The Thoroughbred, or English running horse, is a small, nervous, muscular animal. He is possessed of much endurance at the running gait. He has been bred for sport and racing. His color may be bay, brown, or chestnut.

Horse training. — The pleasure and profit to be derived from the use of a horse will depend on how well he is trained to obey the wishes and orders of his master. The horse has a rather remark-

able memory. If he succeeds in breaking his halter once, he will try to do it many times thereafter. If the first time he is tied he tries to break his halter and fails, he is not likely to try again.

The trainer should be firm and quiet in his handling of a horse, and should always accomplish what he undertakes. The horse must learn from the first that the master's will is to be obeyed.

At the outset the horse should be trained to stand still while being harnessed and hitched. The harness should be put on from the left side and gently but firmly placed in position.

Fig. 134. — A bucking broncho, an unbroken horse of the southwest.

In driving, only a few signals should be used. These should mean exactly the same thing at all times. Signals or commands should always be obeyed. *Whoa* should mean to stop, and nothing else. It should not mean to go slowly or steadily, or even to get ready to stop. *Steady* should be used when it is desired to have the horse go slowly or steadily. *Back* should mean to move back wards, and it should not mean to stop. *Get up* should mean to move forward when the animal has been hitched. These commands should always be spoken clearly so as to be understood by the horse.

Harness. — The work of the horse is accomplished by means of harness. Properly fitted harness adds to the usefulness, of the

horse as well as to his comfort. A well-kept harness adds to the appearance when the horse is hitched.

Harness is used to enable the driver to control the horse, and to enable the horse to control the load — to move it forward and backward. To control the horse, the driver must gain command

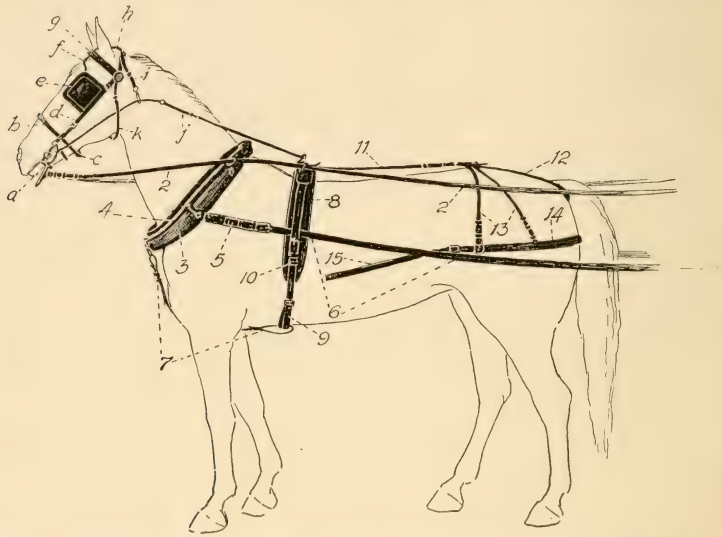

FIG. 135. — Parts of a harness: 1, bridle, having the following pieces: *a*, bit; *b*, nose band; *c*, chin band; *d*, face band; *e*, blinds; *f*, winker braces; *g*, brow band; *h*, crown band; *i*, gag swivel; *j*, side check; *k*, throat latch; 2, lines; 3, collar; 4, hames; 5, hame tugs; 6, traces; 7, martingale; 8, saddle; 9, girth; 10 shaft tug; 11, back strap; 12, crupper; 13, hip strap; 14, breeching; 15, holdback strap.

of the head. This is accomplished through the bridle, and by placing in the mouth a bit to which the lines are attached.

The horse can best control the load from his shoulders. For this purpose the harness is provided with collar, hames, and traces. The breeching and hold-back enable him to back the load.

There are four places in which the harness rubs the body con-

stantly. Unless it is carefully adjusted, these places may become sore. A poorly fitting bridle or a severe bit may cause sore mouth; a poorly fitting collar may cause sore shoulders; a poorly fitting saddle or back-pad may result in a sore back; a poorly fitting crupper may develop a sore tail. Sores give horses much pain. A sore mouth may provoke a horse to run away. Sore shoulders and sore back may provoke balking. Sore tail frequently provokes kicking.

Feeding. — Horses relish good timothy hay, or hay mixed with clover. Corn and oats are the best liked concentrates. Oats are better for driving horses, and corn for work horses. As we learned in the preceeding chapter, the kinds of rations must be adapted to the work the animal has to do; one kind for a draft horse, another for a coach horse, others for driving and race horses.

The food should be provided regularly. Water should be given before feeding, but not while the animal is overheated. In winter it should have the chill taken off.

Grooming. — Nothing adds more to the appearance of a horse than grooming. Since the coat shows so readily the effects of grooming, the body generally receives more attention than the legs. Usually the legs are most in need of grooming. Time spent in cleaning and rubbing the horse in the evening, after the day's work is done, is worth much more than the same length of time spent in the morning, because the horse will rest so much better.

Animals properly groomed, fed, and blanketed in the evening come from the stable in the morning with spirit and vigor. They also are much less likely to develop any of the diseases and difficulties to which the feet and legs of horses are subject.

Problem 193. Make a list of all the different kinds of labor performed on your father's farm by the horse.

Problem 194. Could many of these tasks have been done without the aid of horses? Would it have been more expensive to perform them by other means?

Problem 195. A horse well directed can do as much work as ten men.

Does he earn good board, kind treatment, a comfortable place in which to rest, and careful grooming?

Problem 196. Can you name the parts of the harness and tell what each does?

Problem 197. How many breeds of horses are represented in your locality? How do you tell them apart? Are most of the horses common, mixed stock?

Problem 198. Name the parts of a horse. (Perhaps yonr father will drive a horse to the school-house and explain the parts to all the pupils.)

Problem 199. How would you care for a harness?

CHAPTER XXXV

CATTLE

Cattle are the most important domestic animals of the English-speaking peoples. They are much more necessary than horses. They may be used as beasts of labor, and they supply meat, hides, and milk. From the milk are made butter and cheese and other products of lesser importance.

History. — Our domestic cattle probably have descended from at least three prehistoric races. These races were entirely distinct from one another. One, called the Urus, was domesticated by the Swiss lake-dwellers. It existed in large numbers in the forests of Europe down to the time when history began to be recorded. It is described as being a little smaller than an elephant, but resembling a bull in form.

A second prehistoric ancestor was the Celtic ox, which once ran wild in Sweden. It also was bred by the ancient lake-dwellers. It was smaller than our present-day cattle.

The third of the original ancestors was an animal larger than the Celtic ox, that lived with the ox in the forests of Scandinavia. The mountain cattle that are now found in Norway are supposed to have descended from it.

Two races to-day. — Cattle, as they exist among civilized peoples to-day, are of two races. One is the common beef and dairy cattle, which nearly every farm boy and girl in America knows. The other, called zebus, is a race of peculiar looking cattle that are common in India. They have an immense hump of fat over the shoulders, large, drooping ears, and a heavy, loose dewlap hanging

from the underside of the neck and extending from the lower lip back to the chest.

The humped zebus were domesticated in Egypt 2000 years before the Christian era. In India they are now used as beasts of burden and also as saddle animals. They have an easy trot, or gallop, and great endurance, being able to cover sixty or seventy miles in a day. Occasionally a pure white animal is found. It then becomes the sacred bull of India and plays an important part in religious festivals. Zebus are sometimes called sacred cattle. They enjoy a hot, dry climate. A few have been introduced into the southwestern part of the United States.

Beef and dairy cattle. — Cattle are reared in America for two purposes: for the production of milk, and for the production of beef. As these two purposes make different demands on the energies of the animal, they cannot both be developed to their highest condition in one animal. For this reason, there have gradually grown up two distinct types of animals, one which excels in milk production, and another which excels in meat production. We call the one dairy animals and the other beef animals.

But these two types are not wholly distinct, or separate from one another. The cows of the beef type give some milk, and the animals of the dairy type will furnish beef of fairly good quality when fattened. There are a great many animals of intermediate form, that produce beef of fair quality and at the same time are used for milk production. They are spoken of as dual-purpose (two-purpose) or general-purpose animals.

Beef type. — Animals of the beef type are reared for meat. The more meat they can furnish for a given quantity of food, the more profitable they will be. They have been developed with broad, deep, compact, rectangular bodies which are covered thickly and smoothly with flesh (muscle), so that the angles of the bones are nowhere prominent. The neck is short and heavy, and blends smoothly into the shoulders. The

legs are short and set wide apart so as to support a large, heavy body.

Not all beef animals are alike, however. They have been developed from different ancestors and under different geographical conditions. There are now several types, called breeds, among beef

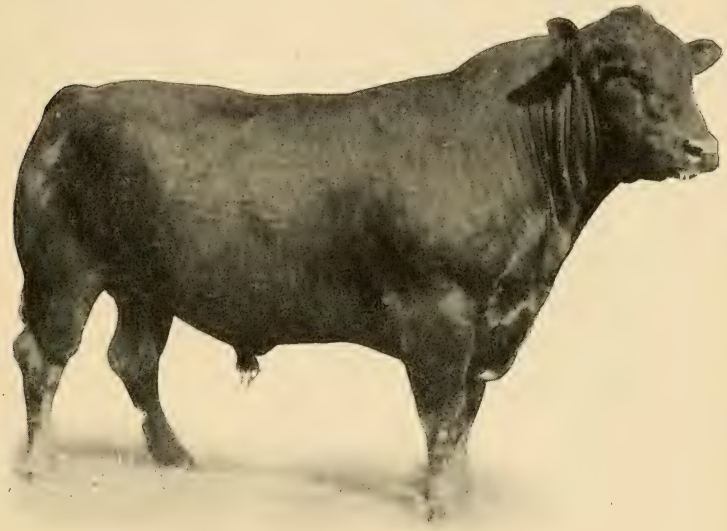

Fig. 136. — Aberdeen-Angus bull. Beef type.

animals. The most common breeds in America are Shorthorn, Aberdeen-Angus, Hereford, and Galloway. All of these breeds originated in Great Britain, and have been imported into America.

The Shorthorn is perhaps the most popular beef breed. It originated in the valley of the Tees River, in the northeastern part of England. It has short, heavy horns, that curve gracefully forward (see frontispiece). In color it varies more than any other breed. It may be white, or red, a mixture of red and white, or roan. The Shorthorn was first imported into the United States in

1783, and into Canada in 1833. It is now the most widely distributed beef breed in America.

The Aberdeen-Angus had its origin the northeastern part of Scotland. Its color is black and it has no horns. It was brought to America in 1872. It is now reared in large numbers in both the United States and Canada.

Fig. 137. — Young Galloway cow. Beef type.

The Galloway is a very ancient breed, which originated from the wild cattle that the Romans found in the forests of Britain when they first visited that country. It takes its name from the province of Galloway in the southeastern part of Scotland. It has a long, soft, shaggy coat of black hair, and is hornless. The shaggy coat easily distinguishes it from the Aberdeen-Angus. The breed first reached Ontario, Canada, in 1853, and later came to the United States.

The Hereford originated in the southwestern part of England, in the county of Hereford. The breed is distinguished by its color markings. The head, including jaws and throat, is white, with white under the neck, down the breast, under the body, and more or less on the legs. The bush of the tail also is white. There is a

white strip on the top of the neck from about the middle to the top of the shoulders. The remainder of the body is red. The coat of hair is long, soft, and curly.

The Hereford first reached America in 1817. It is now one of the leading beef breeds in Canada, the United States, and Mexico.

Dairy type. – Animals of the dairy type are reared for milk. The less flesh they carry the better, as it is desired that all the surplus food-energy shall go for the production of milk and not for the production of meat. The body of a good dairy animal is narrower before than behind; that is, it appears wedge-shaped as we view the animal from the side, with the smaller end of the wedge toward the front. This is caused by a large development of the rear quarters, and by rather low, thin shoulders. The animal has a spare, angular appearance because of the lack of muscular development. The angles and joints of the bones are prominent. This does not mean that the animal is poor, for there may still be abundant fat stored in the body.

There are several distinct breeds of dairy cattle for the same reason that there are separate beef breeds. The more common breeds in America are Jersey, Guernsey, Holstein-Friesian, and Ayrshire. Dutch Belted and French Canadian cattle are found in smaller numbers.

Jersey cattle originated on the island of Jersey in the English Channel. They are rather small, quiet animals, but not lacking in spirit. The horns are small and crumpled, or incurving. The body is well-rounded, large, and deep. The color is soft gray brown, or fawn. The breed was first imported into America in 1850. It has increased so rapidly in this country that there are now more in America than on the island of Jersey.

Guernsey cattle originated on the island of Gurnsey, near the island of Jersey, in the English Channel. They are slightly larger than Jerseys. Their color is a shade of fawn with white markings. It is supposed that they were first brought to America in 1818.

They are most numerous in this country in the northern part of the United States and Canada.

Holstein-Friesian cattle had their origin among the ancient Friesland people, a tribe which, at the time of our earliest historical knowledge of it, occupied the shores of the North Sea. The Friesians were the oldest inhabitants of Holland. Holstein-Friesian cattle are the largest of the dairy breeds, and are black

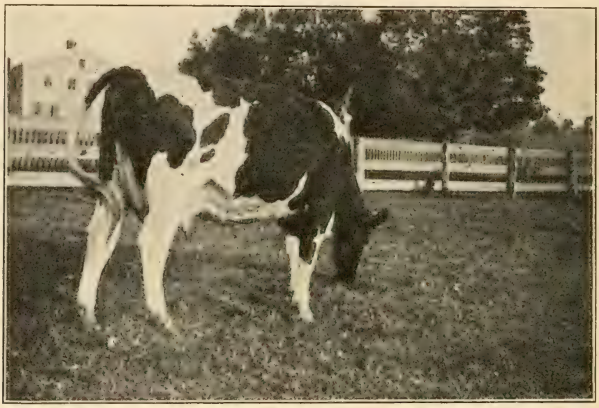

FIG. 138. — Holstein-Friesian cow. Dairy type.

and white in color. It is probable that a few animals were brought to America by the early Dutch settlers. There were few of them in this country earlier than fifty years ago. The breed is now scattered throughout the United States and Canada.

Ayrshire cattle were developed in the county of Ayr, in Scotland. They are of medium size, and somewhat less angular than Jersey or Holstein cattle. The common color in America is red and white patches, with rather more white than red. They first reached America between 1820 and 1830. Ayrshires have been especially popular in Canada.

Feeding and care of cattle. — We have learned that it is a severe tax on a dairy cow to produce milk. The more milk she

yields to the pound of food the more valuable she is to her owner, and the heavier the tax on her system. She is expected to be ready twice a day with a good yield of milk. In order to do so, she must have kind treatment, regular milking, and watering and feeding, and plenty of nourishing food.

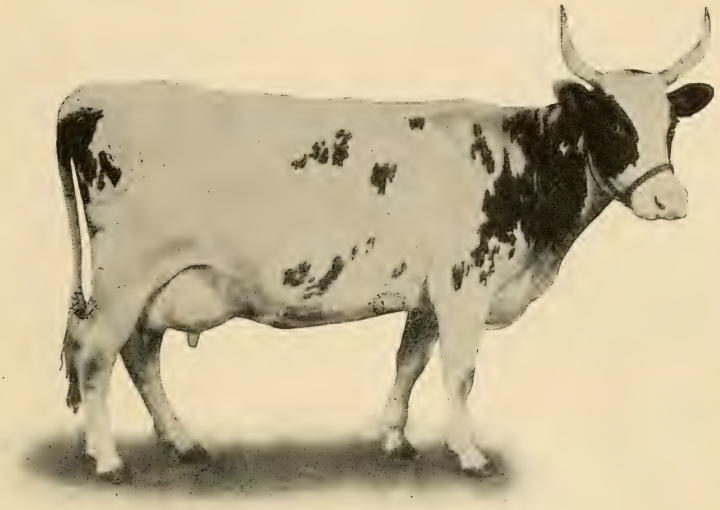

Fig. 139. — Ayrshire cow. Dairy type.

In the summer, when dairy cattle are at pasture, they need little else except when the pasture becomes short and dry. Then corn, alfalfa, peas, oats, rye, rape, and a few other crops may be cut while green and fed to them. In the winter, they relish well-made timothy, clover, alfalfa, or other kinds of hay, corn fodder, silage, root crops, and concentrates or grain feeds. If possible the ration should contain some hay and other dry forage, a succulent food, as silage or roots, and some grain. The careful farmer will feed a properly balanced ration.

Beef cattle are given such foods as will make them fat most quickly and at least expense. Sometimes they are fed fattening foods as soon after birth as they are able to digest them, and are kept on fattening foods until they are ready for market. They may then be made ready for market when ten to sixteen months old. Other cattle are allowed the freedom of the range or pasture

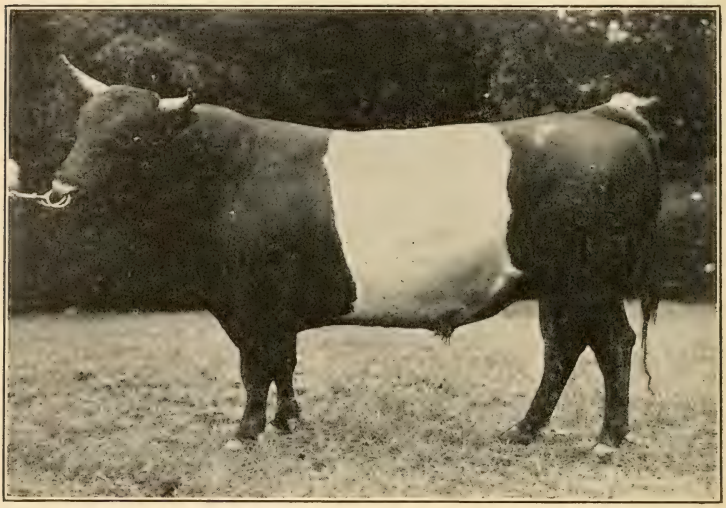

FIG. 140. — Dutch Belted bull. Dairy type.

for a few months or a year or two, and are given fattening foods for a period just before they are to be marketed. Corn is the chief fattening food, with the addition sometimes of oats, oil meal, gluten meal, or other concentrates. Corn fodder, silage, clover, alfalfa, cowpeas, and other kinds of forage are also fed.

In the central and middle western states, the feeding of cattle for market has been developed on a very extensive scale. Formerly they were allowed to feed in great droves over the broad unfenced country, being attended by cowboys; but now that the Great

West is becoming settled and fenced, the cattle are more confined to regular farms, and the days of "ranging" are passing away.

Problem 200. Do the farmer's in your locality raise dairy or beef cattle? If most of them raise dairy cattle, are there any small herds of beef or dual-purpose cattle?

Problem 201. What kinds of products are received from the cattle raised in your locality? Are the products used in the locality or shipped away? If shipped, how are they prepared for shipping?

Problem 202. If there is a creamery, find out how much milk and butter is handled each day, and what becomes of the butter. Find out how the farmers are paid — on what basis. If there is a skimming station, secure similar information from it.

Problem 203. Of what value are cattle to the farmer and his farm aside from the dairy or beef products he gets from them?

Problem 204. Ask the teacher to take the class to the best stock-farm in the neighborhood, and have the owner show the class the points of a good cow. Ask him about the ration he feeds.

Problem 205. Name the different breeds of cattle represented on the farms in the locality. Describe how one breed differs from another.

Problem 206. Make an estimate of the number of cattle in your school district; and estimate how many are giving milk, how many are fattening for beef, and how many are young stock?

CHAPTER XXXVI

SHEEP

Our earliest records tell of shepherds keeping watch over their flocks of sheep. The first animals mentioned in the Bible are sheep. Abraham's wealth was measured by his "sheep and oxen and camels." This useful little animal has known a long period of domestication. It has furnished food and clothing for many races of men. Special distinction has attached to it because of its ancient use for sacrificial purposes in religious worship.

Fig. 141. — The musmon, one of the wild ancestors of our domestic sheep.

History. — On the elevated plains of Asia, from the Caucasus northward and eastward to Kamchatka and the ocean, roam many small flocks of wild sheep, or *argali* as they are called. They are larger than our common sheep, with enormous horns sometimes a foot in circumference at the base and three to four feet long. The wool is brown, with a buff-colored streak along the back and a large spot of buff color on the

haunch. These animals are agile and strong, but wary and suspicious. They are hunted for their flesh and their skins, which are made into clothing.

In the mountains of Greece, and on the islands of Crete, Cyprus, Corsica, and Sardinia, are found other large herds of animals much smaller than the argali, and also less powerful and less active. They also are wild sheep, and are called by the name *musmon* or *mouflon*.

It is thought that domestic sheep are descended from these two wild forms. Like the argali and the musmon, domestic sheep are mountain and highland animals, or they do best in cool climates. They are able to thrive on steep rocky hillsides, mountain-sides, and other rough lands inaccessible to the plow.

The wild sheep of America have not had part in the formation of our domestic breeds.

There are many types of sheep. — As is to be expected of an animal that has been long under domestication in many countries, the sheep presents many types or forms. Some have two horns, others three, others four or more, and others none. Some have short tails, others have long tails, and one breed in Asia has a very thick, fat tail. There are large races and dwarf races. Some kinds have a heavy double coat, and in tropical regions there are woolless sheep.

The great variety in domestic sheep illustrates how animals in nature adapt themselves to the conditions in which they live. The adaptability of the sheep has found for it a place in nearly every part of the world.

Sheep may be classified according to use. — Sheep are raised for wool and for meat. Some types that yielded finer fleece than others have been developed for their wool, so that we now have special wool breeds. Others, which furnished a fine quality of mutton, were bred principally for this character and so we have also mutton breeds.

Practically all of our domestic sheep belong in either one of

these two groups. But these two classes are not distinct. Wool is sheared from the mutton breeds and mutton is the final disposition of most of the wool breeds.

Since all domestic sheep in America yield some wool, it is more common to classify them according to length or quality of fleece. Three classes are given: fine wool, medium wool, and long wool. The fine-wool sheep are the best wool breeds, and the other two classes are the mutton breeds.

The breeds of sheep. — In America we have the following breeds of sheep:

(1) Fine-wool breeds: American Merino, Delaine Merino, and Rambouillet or French Merino.

Fig. 142. — American Merino ram.

FIG. 143. — Hampshire Down ram.

FIG. 144. — Oxford Down ram.

(2) Medium-wool breeds: Dorset Horn, Hampshire Down, Oxford Down, Shropshire Down, Southdown, Suffolk Down, and Tunis.

(3) Long-wool breeds: Cheviot, Cotswold, Leicester, and Lincoln.

Wool production. — Next to cotton, wool is the product most extensively used in the manufacture of cloth, felt, and other fabrics. It is estimated that in 1900 the world's wool clip was 2,685,000,000

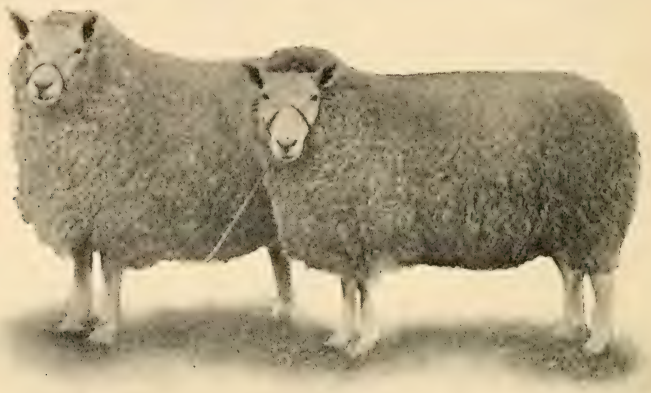

Fig. 145. — Cheviot ewes.

pounds. Argentina, Australia, America, Russia, Great Britain, and British India are the leading wool-producing countries.

For many years sheep-breeders in America paid much attention to the production of fine wool. In 1893, the price of wool became very low, and many breeders, especially in the middle and eastern states, abandoned wool production and undertook to produce mutton. On the ranches of the west and the southwest, wool-growing is now receiving much attention again. The wild pastures that are too scant for cattle are yet valuable for sheep-raising. The ranchman can place wool on the market at much less expense

than he can raise mutton. Many breeders ship lambs east for fattening for market.

Mutton production. — The rearing and feeding of sheep for the production of mutton is to-day an important industry in America. In 1907, there were 3,069,391 sheep slaughtered at the Union Stock

FIG. 146. — Lincoln ram.

Yards in Chicago alone. Large numbers were slaughtered at many other points.

Sometimes lambs are "forced," or fattened from their birth until they are six to ten weeks old. They are commonly called "hot-house" lambs. They furnish the finest quality of mutton and bring high prices. They require special buildings and much care in their rearing.

More commonly sheep are allowed to run on pasture during the

summer, and are given a small amount of grain. They are slaughtered in the fall before it is time to house them for the winter.

Another method of producing mutton is to fatten western lambs that have been allowed to run on the free range until eight or twenty months old. They are then shipped to eastern farms. Here they are fed corn, clover, or mixed hay. Sometimes oats, peas, and barley are given. This method is increasing in importance and extent. The western man makes his money on the

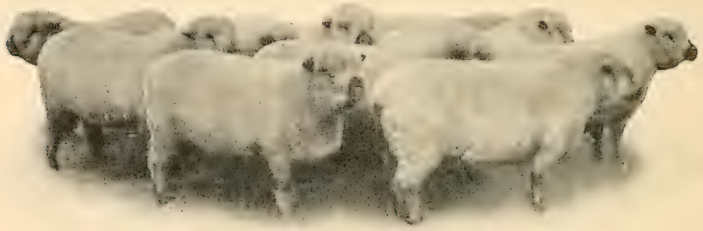

Fig. 147. — Shropshire lamb ewes.

raising of the sheep and on the use of his pasture; the eastern man makes his profit on the feed that he raises or buys.

Sheep-farming in America. — In the East sheep are kept in small flocks within fenced fields, and in winter are housed in regular barns. In the West great sheep ranches have been developed. Sheep-farming as an industry is now largely a business of the West. Formerly the sheep were pastured on the open unfenced range (or public domain); but now they are mostly confined to large privately-owned ranches, at least during some part of the year.

In the mountain states of the West the sheep are pastured on the highlands in summer, often above the timber-land and near the snow-line, and on the plains or in the valleys in winter. Immense flocks or "bands" are kept, which are moved from

place to place to secure pasturage. Men with camp equipments and sheep dogs move with the flocks. The sheep are sheared just before they go to the summer range.

Problem 207. Write or explain how the sheep, if any, are raised in your locality: on what lands they are pastured, when they are housed, what they are fed, what becomes of the wool and the mutton.

Problem 208. Name and describe any breeds of sheep with which you are familiar.

Problem 209. Do sheep require much attention? In what ways are they useful on the farm?

Problem 210. If sheep have been shipped into your locality for fattening, find where they came from, how they had lived before, what they are now being fed, where and when they will be marketed.

Problem 211. If the mother dies, or will not own the lamb, how would you save the lamb?

Problem 212. What sort of foot has a sheep?

Problem 213. How much may a full-grown sheep weigh?

CHAPTER XXXVII

SWINE

Swine, or hogs as they are more often called in America, have long endured an unenviable reputation. In ancient time, Moses was instructed to have his people abstain from eating pork because it was unclean. Wherever hogs are kept in small numbers they are likely to be given poor houses and small yards; and the fact that they are able to make such good use of waste materials from the kitchen and farm has added further to their lowly reputation.

But, as we shall see, hogs are naturally clean in their habits, and will keep their houses clean and in order when it is made possible for them to do so. If we view them aright to-day, we must exalt their position somewhat. We are all dependent on them, either for lard or for pork, or for both.

History. — The exact origin of swine is not certainly known. They belong to a family of animals that inhabit tropical countries mostly. It is thought that the farm hog has descended from the wild boar of Europe, North Africa, and Asia. Perhaps, also, a native race in India has had part in its development.

It is probable that hogs were first domesticated in Asia. They are now very widely scattered. They have a tendency to return to a wild state when kept in mild climates. This is well shown by the wild razorback hogs found in a few places in the southern part of the United States. They doubtless have developed from hogs brought to America by early settlers and which escaped from domestication or were allowed to roam freely in the woods.

The wild boar is still found in central and southern Europe and

Asia. From the earliest times it has been a much sought game animal, the boar hunt being one of the leading pastimes of royal and noble families. The boar is a swift and fierce animal, larger than our common hog. Its great tusks are dangerous weapons. When pursued it becomes ferocious and will attack both men and dogs.

Under domestication the hog has been much changed. It is now quiet and docile, although old boars will still become vicious when aroused. The wild hog was not a fleshy animal, but the domestic hog has developed remarkable ability to fatten. Frequently it will fatten so much that its legs can scarcely support it and it is able to move about only with difficulty.

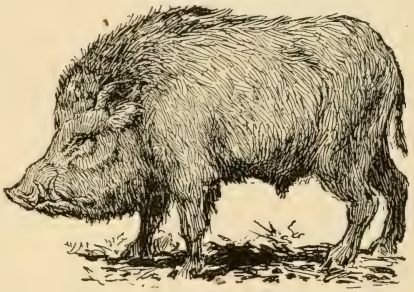

Fig. 148. — The wild boar from which our present-day swine have descended.

The male of swine is known as a boar; the female as a sow. A young pig, particularly after weaning, is called a shoat or shote.

The nature of hogs. — Unlike other domestic animals, the hog has almost no covering for his body. The few bristles and hairs do not protect him from the attacks of flies and other insects. Furthermore, the hog does not perspire as a horse does. Thus it is that he has learned to wallow in water and mud to rid his body of pests and to keep it cool. Hogs that are kept in woods or groves have less need for the wallow.

When hogs are given large yards or free range, and have a clean place in their houses for sleeping, they will keep their bedrooms neat and clean. It is only when the small pen is made to serve as dining-room, bed-room, and wallow, all in one, that the pig is filthy. That is not his fault. It is the way in which he is kept.

Hogs have always had to dig for much of their food. As some

of this food was the roots of plants, the name "rooting" has been applied to the method by which they secured this part of their food. The strong, fleshy disk on the nose has been developed for this purpose. Not only is it able to stand the wear

Fig. 149. — Chester white.

of rooting, but it is very sensitive to smell and can readily detect what the animal is looking for. A pig will follow a track or trail almost as well as will a dog.

Classification of hogs. — Hogs are raised for lard and bacon, and it is usual to divide them into two classes: lard or fat hogs, and

Fig. 150. — Berkshire.

Fig. 151. — Cheshire.

bacon hogs. These two classes overlap, as some hogs are useful for both purposes.

Sometimes swine are classified simply according to size into

large breeds, medium breeds, and small breeds. Sometimes they are classified as white, black, and red hogs.

Breeds of hogs. — The more common breeds in America are as follows:

(1) Lard hogs: *Berkshire*, a black animal with white markings and ears extending erect; *Chester White*, a white hog with drooping ears; *Cheshire*, white with erect ears; *Duroc-Jersey*, red or chestnut with drooping ears; *Essex*, black with small, fine, erect ears; *Poland China*, black and white with drooping ears; *Victoria*, white, with occasional dark spots on the skin, and erect ears. The Cheshire, Chester White, Duroc-Jersey, Poland China, and Victoria breeds were originated in America.

Fig. 152. — Poland China.

(2) Bacon hogs: *Hampshire*, usually black with a white belt, four to twelve inches wide, encircling the body and including the fore legs; ears inclined forward; *Large Yorkshire*, white with erect ears; *Tamworth*, red or chestnut with large, pointed, erect ears.

Fig. 153. — Hampshire.

If we classify, or group, the breeds of hogs according to size, they will be arranged as follows:

(1) Large breeds: Chester White, Large Yorkshire, and Tamworth.

(2) Medium breeds: Berkshire, Cheshire, Duroc Jersey, Hampshire, Poland China, and Victoria.

(3) Small breeds: Essex.

The rearing of hogs. — When hogs are allowed to roam in the woods, they will live on roots and nuts, especially acorns and beechnuts. The beechnut bacon of the semi-wild hogs of the southern states is of very high quality. Hogs will eat almost anything that comes in their way, be it animal or vegetable. On the frontier they once did good service as destroyers of rattlesnakes.

Fig. 154. — Tamworth.

There are two rather distinct, or unlike, methods of raising hogs in America. One is to keep a few animals in small pens and yards to use the wastes from kitchen and farm. This is the common practice in the East. Such hogs are raised largely for home use.

The other method is the raising of hogs in large numbers to supply the market demands. It is practiced in the central west, where there are extensive hog farms. Usually, but not always, hogs are raised on farms on which beef cattle are being fattened for market. The hogs, as well as the cattle, are fattened on corn. For this reason the extensive hog farms are nearly all found in that part of the country where corn is the leading crop, that is, in the corn-belt. The hogs run with the cattle and are able to use the corn which the cattle waste and which otherwise would be lost. It is now coming to be the practice to provide small "colony houses" for hogs. These are small honses or pens scattered about the fields, each accommodating three to six animals. This is for the purpose of guarding against the dreaded hog-cholera disease. When the animals live all together, the disease

is likely to spread rapidly. If it invades one of the houses, the houses may be burned.

Hogs enjoy free range, and when given good clover or alfalfa or rape pasture, will make rapid growth. Wherever they are raised in large numbers, pasture must be provided.

Problem 214. Name and describe the breeds of hogs that are kept in your locality.

Problem 215. What is done with the products from the hogs on farms in your locality? If used at home, how are they prepared and stored? If shipped away, how are they prepared for market?

Problem 216. Tell how the hogs are cared for in your neighborhood — how they are housed, what pasture they have, what they are fed, how expensive it is to raise them.

Problem 217. Watch the hogs for a few days and then tell what you have observed as to their habits, especially with reference to the care of the body. See whether you can find any indications that hogs like to have clean living-quarters, especially for sleeping.

Problem 218. What kind of fence is needed to confined hogs?

Problem 219. What is meant by "pork on the hoof"? How much is it worth in your neighborhood now?

Problem 220. What is a pig's foot like?

Problem 221. Can you tell the difference between a pig's track and a sheep's track? How?

Problem 222. How heavy (what weight) was the largest hog you ever saw?

CHAPTER XXXVIII

POULTRY

Not long ago poultry was a part of the farm stock of which no account whatever was taken. The fowls lived on refuse and such food as they could find on free range. Whatever they produced in the way of meat, eggs, and feathers was looked upon as clear gain. Because they thrived everywhere, cost very little to keep, multiplied rapidly, and returned a marketable product, they found a place on nearly every farm. Fowls are kept to-day on more farms or homesteads than any other domestic animals except cats.

Farm poultry is of several kinds. Domestic fowls, or chickens, are the most common. Turkeys, ducks, geese, and guinea-fowls are reared in small flocks on many farms, and ducks and geese in large numbers on special farms.

The origin of the domestic fowls. — The domestic, or barnyard fowl, as it has been called, belongs to a race of scratching birds that includes also the turkey, guinea-fowl, pheasant, partridge, and grouse. Its origin seems to trace largely to a wild form called the jungle fowl, still common in the jungles of India, southern China, and the East Indies. This wild bird has a slender body and a single comb and is able to fly considerable distances.

Another wild form also seems to have contributed to the early development of domestic fowls. It was the very ancient ancestor of the Aseel, or Malay fowl, which has been bred in India for more than 3000 years. It has a larger body than the jungle fowl, a triple or pea comb, and yellow-skinned legs. It does not fly great distances.

The history of the domesticated fowl reaches far back into the past. About 1400 B.C. the fowl moved northward and eastward from southeastern India into China. Later it passed into Japan. Records that date 1000 B.C. mention cock-fighting as a pastime. It is not mentioned in the Old Testament, as are horses, cattle, sheep, and swine. But this is because it did not reach Syria until 300 or 400 years before the beginning of the present era.

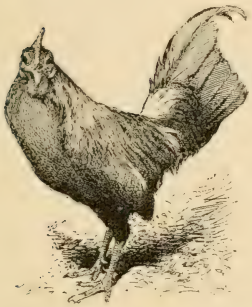

FIG. 155. — The red jungle fowl, from which domestic fowls have come.

FIG. 156. — The Aseel fowl, one of the original ancestors of domestic fowl.

About 330 B.C., domestic fowls were taken to Europe from Persia. There they spread rapidly. From Europe they were brought to America in the early days of the colonization. Game fowls, Leghorns, Dorkings, and Scotch Grays were brought over by the colonists. From the Scotch Gray the Barred Plymouth Rock was developed. Later, Brahmas were imported from the Brahmapootra River, and Cochins from Shanghai.

The nature of fowls. — It is the nature of fowls to "scratch for a living." For that purpose the legs are long and muscular, protected by horny scales, and the strong, flexible toes are armed with horny claws. Even when well fed they prefer to spend

much of the day in scratching for food, especially for insects, grubs, and earthworms.

Chickens are not provided with teeth and must swallow their food whole. It passes into the crop, where it is softened by juices. Then it passes into the gizzard — a veritable mill filled with gravel which the fowl has swallowed and which grinds the food into fine particles for digestion.

FIG. 157. — Shelter from all harm — sunshine, rain, or danger.

A chicken has no muscles in its throat to enable it to swallow water. It must first fill its beak and then hold its head up so that the water may run down its throat.

In early spring, the hen begins to lay regularly, depositing not more than one egg each day. If allowed to follow her natural tendencies, she would cease laying and begin to sit as soon as she had accumulated a nest full — twelve to fifteen eggs. By re-

moving the eggs each day, the laying season may be lengthened several weeks or months. Domestic fowls have been developed by man to lay many eggs instead of only enough at a time for one brood.

The dust bath, of which fowls are so fond, is very necessary for their health. It helps to relieve them from vermin, and cleanses the skin. It is nature that has taught hogs to wallow and fowls to use the dust bath for health and protection.

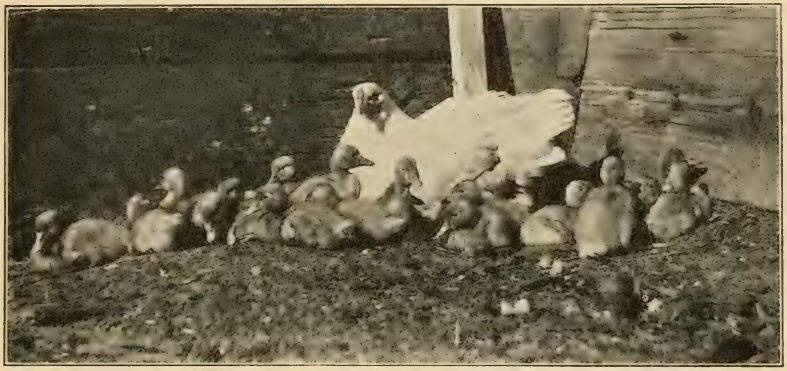

Fig. 158. — Hen and ducklings.

Breeds of poultry. — As there are beef and dairy types of cattle and wool and mutton types of sheep, so there are meat and egg types of chickens; that is, some types have been developed to fatten for meat purposes, and others to lay many eggs. All fowls lay eggs, but the meat types usually do not lay large numbers. There are also dual-purpose (two-purpose) fowls just as there are dual-purpose cattle; that is, some fowls are raised both for eggs and for meat, and are valuable for both.

More families, breeds, and varieties of poultry have been developed than of any other kind of live-stock. Most of them are raised for profit. Some have been bred merely for fancy or pleasure. Others have useful qualities, but have not become popular.

The majority, but not all, of the breeds that are raised in America belong to one of two families, the American and the Mediterranean families.

The American family includes the Plymouth Rock, Wyandotte, and Rhode Island Red, and the Dominique and Java of lesser importance. These fowls are large and fatten readily for market.

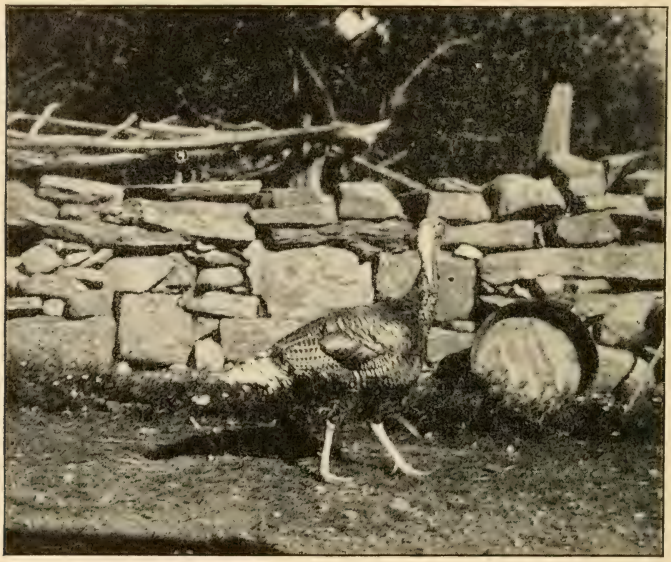

Fig. 159. — A turkey likes to wander through the fields.

They are rather good layers, and perhaps we may call them dual-purpose breeds.

The Mediterranean family includes the Leghorn and the Minorca, and the less important White-faced Black Spanish, Blue Andalusian, and Ancona. These are neat, active fowls that lay large numbers of eggs. They are the true egg breeds. They do not fatten readily.

The Brahma and Cochin, which are true meat breeds, belong to

the Asiatic family. The Orpington, which is now raised in considerable numbers in America, belongs to the English family. It is a dual-purpose breed.

Color of eggs. — Most of the eggs from farm poultry are either brown or white. Brown eggs are laid by Plymouth Rock, Wyandotte, Rhode Island Red, Brahma, and Cochin fowls. White eggs are laid by Leghorn and Minorca fowls. Medium colored or tinted eggs are laid by Dorking and Orpington fowls.

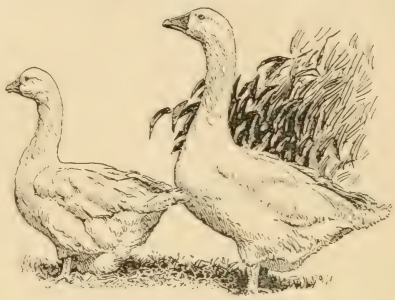

Fig. 160. — Embden geese.

The color of eggs is sometimes an important factor in their sale. Some markets will buy only white-shelled eggs, others only those having brown shells. There is considerable variation in color and shape of eggs, even in the same breed.

The care of poultry. — By nature fowls are able to care for themselves. But by nature they lay few eggs, and are not likely to be fat enough for market when needed.

Fowls that are kept for profit must be fed proper foods, at regular intervals, must have clean, well-ventilated houses, and plenty of room for outdoor exercise. There must be opportunity for scratching and for the dust bath. The natural desire of the hen is to hide her nest, and she should be provided with a secluded place in which to lay her eggs.

All classes of poultry, including domestic fowls, turkeys, ducks, geese, and guineas, eat freely of grain and meat foods and green forage. Domestic fowls eat most freely of grains ; turkeys and guineas are insect-hunters; ducks and geese are grazers and fishers.

Every ration for domestic fowls should contain whole grain, as wheat, corn, oats, or peas; ground feed, as wheat bran, wheat

middlings, corn meal, or ground oats; meat in some form, as beef scraps, green cut bone, or skimmed milk; green food, as clover pasture, mangel beets, or cabbage; and grit, as cracked oyster shells. Fresh, clean drinking water should always be available.

Poultry should be fed properly balanced rations for particular purposes: for eggs, or for meat, or to encourage the production of both. They like variety, and do better when several kinds of food are given. They should have food that they like.

Hatching. — When a small number of chickens are to be raised each year, broody hens may well be used for the hatching. Fowls in the American and Asiatic families are good setters. Those in the Mediterranean family are usually very poor sitters.

Chickens may be hatched in an incubator. This is a machine in which eggs can be kept at the same temperature as when covered by a hen. Chickens hatched in an incubator are frequently reared in another machine, called a brooder, until they are able to care for themselves. A brooder takes the place of the mother by supplying for the chicks protection and the right degree of heat. Incubators and brooders are used mostly when chickens are reared in large numbers.

About twenty-one days are required for hatching the eggs of domestic fowls.

Problem 223. How does the covering, or coat, of fowls differ from the covering of other domestic animals? What advantage over other animals does this give to fowls?

Problem 224. On how many farms in your locality are chickens kept? Are they in large flocks or small flocks? How are they cared for?

Problem 225. If there are any farms in your neighborhood on which poultry are raised in large numbers, find out how they are taken care of. Explain the differences between handling very large flocks and small flocks.

Problem 226. Name and describe all the types and breeds of poultry reared in your locality so far as you are able. Tell which are meat breeds, which egg breeds, which dual-purpose breeds.

Problem 227. If eggs are shipped from your neighborhood, find whether the market to which they go has any preference as to color.

CHAPTER XXXIX

BEES

The raising of honey bees has always been one of the occupations of man. In the book of Genesis we read that when Jacob sent his sons down into Egypt to buy corn, he told them to take with them, among other things, "a little honey." Up until the seventeenth century honey was the only means people had for sweetening their food, as sugar was unknown.

The development of bee-keeping. — Ancient Egypt, Babylon, Assyria, Palestine, Greece, Rome, and Carthage, all had their bee-keepers. The keeping of bees in Egypt to-day is probably not very different from what it was four thousand years ago. At that time floating apiaries were common in Egypt, and they are still found on the Nile.

The raising of bees has received a great deal of attention down through the centuries, and more books have been written about bees than about any other domestic animal. It was not until 1852, however, that the production of honey as a great commercial industry began. In that year Mr. Langstroth, of Philadelphia, invented a new kind of hive that greatly changed the methods of keeping bees, and made it possible for one person to manage a large number of hives. It is said that the Langstroth hive has meant as much to bee-keeping as the invention of the locomotive has to transportation. Most of the hives in use to-day are fashioned after the one made by Mr. Langstroth.

The keeping of bees for honey is now a large industry in America. In almost every community there is at least one apiary, or place where bees are kept. The honey and wax produced each year in

the United States is valued at about $25,000,000. In one year, California exported five hundred carloads of honey. Single bee-keepers have produced as much as eighty tons in a year.

There are different types of bees. — Bees, like other insects and animals that have existed for many centuries and in various parts of the world, have developed many varieties or races. They are of different sizes, shapes, colors, and habits. Some are wild forms

Fig. 161. — The keeping of bees is one of the farm industries.

that have never been domesticated by man. Most of them have stings, but there are races of stingless bees in South America, some of which have been imported to this country.

The most popular honey bees in America are the Italians, whose original home was in Italy. There were brought to this country in 1860. A race known as Carniolan has found favor in cool, elevated

places in the northern part of America. Several other races are kept in a small way.

The bee colony. — Bees live together in very great numbers, in well-ordered households, or colonies. If the affairs of their colonies were not well ordered, they could not live together. Their government is peculiar, however, in that in each colony there are many kings and only one queen. The kings do little or no work, while the queen works as hard and longer than any of her subjects. The common citizens are all females, and they are busy all the day long.

The number of bees in a colony will vary. There should be at least 40,000 in a colony that is in good condition. Most of them are workers, a few hundred are drones or kings, and there is only the one queen.

The queen. — The mistress of the hive is a very graceful insect, with a long pointed body that extends far beyond the tips of her closed wings. She is the largest member of the household. She starts her life in an ordinary worker egg. This egg is selected by the worker bees for special attention throughout its development. After the queen is three days old from the egg she is fed on a special food called "royal jelly." After feasting on this for five days her cell is closed and she undergoes further development. When she finally emerges, she is full-grown.

The first task of the new queen is to hunt for other queen cells, and, if any are found, to sting the occupants to death. If she finds another fully developed queen in the hive, war is waged between them until one is killed. If the workers interfere in the fight, she takes her followers from the hive to a new home.

The queen is responsible for maintaining the colony. She will lay as many as 3000, and occasionally 5000, eggs in a day. During her lifetime she may deposit 1,500,000 to 2,500,000 eggs.

The workers. — The workers are the citizens of the colony, and are the smallest members of the household. They are all females, but unlike the queen, which received special attention, they are

not perfectly developed and cannot lay eggs. Only the queen has this power. The workers are provided with long tongues, by means of which they can reach deep into flowers to gather the nectar. This they deposit in pollen or nectar baskets on their hind legs for transportation to the hive for storing.

The drone. — The drone is the king, whose only responsibility is to mate with the queen. Even though he is an idler, he is a very necesary part of the household. He is perfectly developed for his purpose, is larger than the worker, and broader and more blunt in form than either the queen or the worker. He has no pollen baskets and no sting. His tongue is not long enough to gather honey from flowers. He has no responsibility for the food supply of the colony.

How bees live and work. — Wild bees live in hollow logs and in caves. Those that have been domesticated are provided with houses, called hives. A hive usually is a box, on top of which one or two stories, called "supers," are placed. In the lower story, or box part of the hive, are placed frames which the bees fill with comb, in which the queen may deposit eggs for the new brood. On these frames a considerable supply of honey is stored also. The supers are filled with box-like frames, called sections, each of which will hold a pound of honey. By nature, bees place their brood in the lower part of their nests and most of their reserve honey above. Bee-keepers take advantage of this fact, and remove the sections from the supers as soon as they are filled and replace them with empty ones. It is not safe to take all the honey from the brood chamber below, as twenty-five or thirty pounds will be needed by the colony for winter use.

Honey is made from the nectar of flowers, gathered by bees. The nectar is carried in small receptacles with which bees are provided. Here it is mixed with a secretion made by the bee that produces changes in the nectar which result in the formation of honey. After the honey has been deposited in the comb, it is exposed to the air for a while before it is capped. This ripens it.

Comb foundation. — The honey comb, in which the honey is stored, is made up of long, tube-like cells that are six-sided. When the sections are removed from the supers and replaced by new ones, or when new brood frames are placed in the lower part of the hive, to accomodate the young, the bee-keeper furnishes the sections and frames with what is called comb foundation, or foundation for the building of new comb. This is a thin sheet of beeswax which has been pressed by a machine that has covered its entire surface with a net-work of impressions of the six-sided cells. From these impressions the new cells are built.

The skilful bee-keeper usually fills the brood frames completely with the comb foundation. In the pound sections, ordinarily only a small piece, called a "starter," is used. Bees naturally dislike small frames such as those in the pound sections, but when they find foundation in them, they proceed to fill them out.

Swarming. — Bees will swarm when there are two queens and one is unable to destroy the other. In such an event, part of the colony will leave the hive with one of them in search of a new home.

But this is not the only cause of swarming. Bees will swarm when they have become over-prosperous. When there is an abundance of food on hand and numerous young bees in process of growth, the queen, accompanied by the larger part of her colony, will rush from the hive to give vent to pent-up energy. They go forth with their sacs filled with honey. They maneuver in the air for a while, then settle on a branch or bush near by, at the same time sending out scouts to find a suitable home in a hollow tree or elsewhere. Then it is that the bee-keeper gives them a hive merely by shaking them into it or down in front of an enlarged entrance. They are glad to find a home so soon, particularly if it is clean, and usually will take possession at once.

By removing part of the accumulated honey, so that the bees are kept at work, they may sometimes be prevented from swarming.

Protecting the colony. — Bees must be protected from the cold in winter or they may perish. The best method is to use the "box"

hive in which the inner part, or real hive, is surrounded by an outer case which leaves a space between the two to be filled with chaff or other good packing material. A small opening is left so that the bees can go out in good weather.

FIG. 162. — Swarm of bees on limb of a cherry-tree.

The packing is left in the case during the summer as well as the winter, as it helps to protect the hives from the hot sun. The hives should be placed during the summer where they will be shaded part of the day. The grass should be cut around them so that the

honey-laden bees will not become entangled when they return to the hive.

Problem 228. If you have ever found a wild bees' nest, tell where you found it and how it was protected; what the comb looked like; whether the honey tasted the same as that from domesticated bees.

Problem 229. If bees are kept by any one in the neighborhood, ask him to show you a hive where the bees are at work. Look for the cells in which young bees are developing. Find out what a brood frame is, a section, a super, and comb foundation.

Problem 230. Does all honey that is offered for sale look and taste alike? Is some lighter colored than other? What is the cause of the difference?

Problem 231. Name five plants from which honey bees secure nectar.

CHAPTER XL

MILK AND ITS PRODUCTS

Every household uses milk. Nearly every farm produces milk. Dairying is one of the most extensive industries in America.

What milk is. — We all know that milk is nature's food for the newly born of many of the larger animals. Frequently the young are fed little except milk for many months, and during these months make rapid growth. This is because milk is a nearly perfect food.

The value of any product for food depends on the kinds and amount of nutriment, or nourishing food substances, it contains, and the form in which the nutriment exists; that is, whether it is easily digested and made use of in the body. Milk contains all of the food materials that are needed for the development of the body and they are in a very easily digested form. There is water, which is necessary for all growth; ash or mineral matter, for the making of bones; protein, for the production of flesh and muscle; fat and sugar, to supply heat and energy.

When we speak of the *composition* of milk, we mean the proportions, or relative amounts, of these several materials, or constitutents, that are present. The composition is usually stated in percentages, as that is the best method of comparing proportions. The percentages are not exactly the same for the different breeds of cows or for individual cows. That is one reason why some are better milk-producers than others. But if we average the composition for all of them, we shall find that milk contains,

in round numbers, approximately the following proportions of materials:

4	per cent fat
2.6	per cent casein
.7	per cent albumen
5	per cent sugar
.7	per cent ash
87	per cent water
100	

Some of these substances may be new to us, but we shall learn what they are.

The fat. — If we were to examine milk under a very strong microscope, we should find that there are floating in it, that is, in the

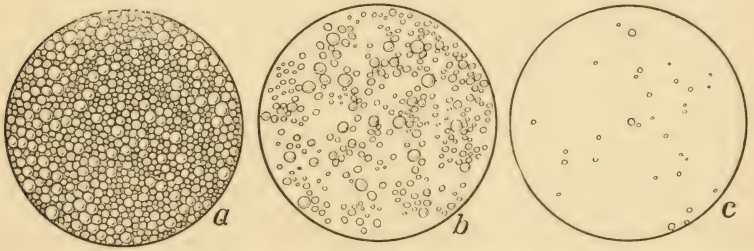

FIG. 163. — An enlarged view of cream, whole milk, and skimmed milk under the microscope, showing the relative number of particles of fat in each. *a*, represents cream; *b*, whole milk; *c*, skimmed milk.

fluid, or watery part of it, many small round bodies of different sizes. These floating bodies are minute particles, called globules, of fat. They are so small that there may be as many as 100,000,000 of them in a single drop of milk.

Although fat usually makes up only about 4 per cent of average milk, it is still the most valuable part. It is the substance from which butter is made. It is part of cheese also and the value of cheese may depend on the amount of fat that it contains. Great

quantities of milk are bought and sold for prices that are determined by the amount of fat present. In most states there are laws which specify that milk offered for sale must contain at least a certain amount of fat. Usually, 3 or 3.25 per cent is the lowest amount that is allowed. Milk may contain as much as 6 per cent, or more.

Cream is largely composed of fat. When we skim or separate milk, we remove the fat in the cream. The cream contains also small amounts of all the other substances in milk, which are removed with fat. "Thin" cream contains a relatively large percentage of these other substances. "Heavy" or "thick" cream is rich in fat and contains much less of the other constituents.

Casein. — This is the part of milk which curdles when milk sours. It does not float, as does the fat, but is partially dissolved, and is somewhat in the condition of thin jelly. It helps to make milk "thicker" than water. After cream has been taken from milk, the most valuable part remaining is casein. It is this substance which makes skimmed milk and buttermilk valuable for human or animal food. It contains nitrogen, and is therefore proteid food.

Albumen. — This part of the milk is much the same thing as the white of egg. Like the casein, it also contains nitrogen, and is therefore a valuable food element.

Sugar. — Milk contains more sugar than fat. It is not just like granulated sugar, but has many of the same characteristics.

The sugar can be separated from milk. It is used by druggists for covering "sugar-coated" pills. Because it is so easily digested, it is used also in the manufacture of infants' foods.

Ash. — Ash is the mineral part of milk, and is especially useful in the formation of bones. It is grayish white in color.

Skimmed milk is milk from which part or nearly all the fat has been removed, or skimmed. It is seldom possible to remove every bit of the fat. Skimmed milk therefore contains the same

substances as whole milk, except that there is less fat. For this reason it still has much food value.

Buttermilk is the liquid part that remains from the churning of cream into butter. Its composition is nearly the same as that of skimmed milk except that it contains more fat. It is unlike skimmed milk, however, because cream is usually sour before it is churned. Souring changes the form of some of the casein and the sugar.

The weight of milk — Milk is slightly heavier than water because of the substances it contains. Since it is largely water, the in-

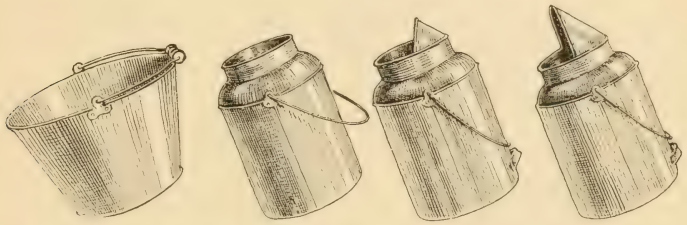

FIG. 164. — Different kinds of milking pails. The one at the left allows the most dirt and dust to enter while milking, and the one at the right the least. The latter is the best of the four. It is coming into use.

crease in weight is not very great. If we take enough milk so that the weight of the water in it alone is one pound, the weight of the whole milk will be about 1.032 pounds. That is, milk is about 1.032 times as heavy as water.

The care of milk. — There is no other food product which is so easily made unfit for use as milk. Farmers may lose much of the profit they should receive from their cows because the milk is not produced under the best conditions and handled in the best way.

Milk is most likely to be spoiled by bacteria. We have learned that countless millions of very minute plants, called bacteria, inhabit the soil. Other kinds of bacteria live in milk. Some of those in milk are useful, some harmless, and others harmful.

When milk is kept in a warm place, and sours, it is not heat that

has soured it, but the harmful bacteria, which are most active where it is warm. Cold milk does not sour quickly because the bacteria cannot work where it is cold.

Every bit of dust and dirt that falls into the milk is loaded with

Fig. 165. — Cooling the milk and exposing it to the air. When this is done in a clean place immediately after milking, the milk will keep sweet longer.

bacteria. Hairs and dirt may be brushed into the pail by the milker, either from his clothes or from the animal's body. Dust, chaff, and many other particles that float in the air in stables may fall into the pails while they are exposed. If the milk pails and

cans and strainer cloths are not perfectly clean, they may carry bacteria to the milk. A few bacteria enter milk while it is still in the udder and before it has been drawn.

In order to produce clean milk, in which there will be few bacteria, the cows must be cleaned before milking, the suits and hands of the milkers must be clean, and all pails and other utensils which the milk will touch must be perfectly clean. Bacteria hide in cracks and seams and rusty places in cans, and cannot be killed by washing unless scalding water is used. It is better if the utensils can be exposed to steam after they have been washed. Handling hay or bedding or anything else which will stir up dust in the stable should not be done during or just before milking time.

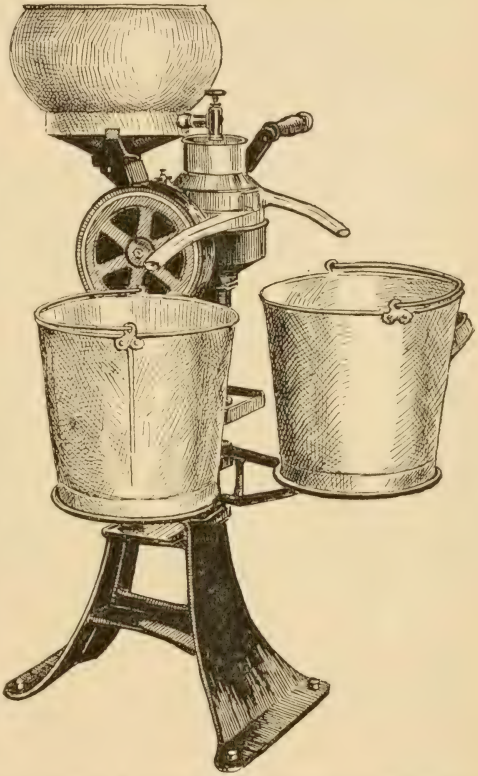

FIG. 166. — A hand separator for use on the farm to remove the cream from the milk.

As soon as possible after milk is drawn it should be taken from the stable. It should be strained at once so as to remove the dirt. It should then be cooled, by placing the can in a tank of cold water, or by other means. No matter how careful the milker has been,

some bacteria will have found their way into the milk. By cooling it as soon as drawn to a temperature of 50° F., the bacteria will be prevented from multiplying. They cannot grow when the milk is cold. If the milk is allowed to remain warm, they will develop rapidly and soon sour it.

Healthy cows, kept in clean, sunny, well-ventilated stables, will do their part in producing clean milk. Most bacteria and

FIG. 167. — Milk in bottles. This is the cleanest way to market milk and cream.

dirt fall in while the milk is being handled, and the farmer himself is responsible for this.

The Babcock test. — Since the market value of milk depends very largely on the percentage of fat it contains, it is a great aid to farmers who produce milk to know how much fat there is in the milk from each of their cows. The milk from some cows contains much fat. That from others contains so little that their milk will not sell for as much as it costs the farmer to keep them. He loses money on every such cow in his herd.

Fortunately, there has been discovered a simple method of finding the percentage of fat in milk. It is called the Babcock test. We

shall learn how it is made in Problem 236. It is now used by very many farmers, and has been the means of saving them many millions of dollars. Dairy farmers who test their milk usually dispose of the cows that do not "pay for their board," and keep only the profitable ones.

Butter and cheese. — The two most important products made

FIG. 168. — An ancient device, said to have been used for churning.

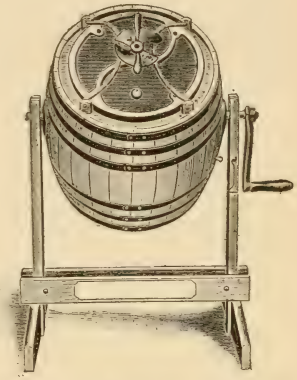

FIG. 169. — A convenient churn for use on the farm.

from milk are butter and cheese. They, like milk, are also used in nearly every household in the land. They are both nutritious foods. Formerly they were made altogether on the farms, but now are manufactured to a large extent in special factories called creameries and cheese factories.

In the making of butter, only cream is used, as butter is made from the fat of milk. Cheese may be made from cream, or the whole milk, or skimmed milk. Most of the cheese we buy at the stores is made from the whole milk.

Problem 232. How many farms in your locality produce milk for sale? Do they sell whole milk or cream? What becomes of the milk they sell? If cream is sold, what use is made of the skimmed milk?

Problem 233. If there is a creamery, cheese factory, or skimming station in your neighborhood, find out how much milk it handles every day, how many cows are required to produce the milk, how it is paid for; also, what is done with the product.

FIG. 170. — Babcock test outfit — centrifugal machine, test bottles, brush for cleaning test bottles, pipette acid measure, sulphuric acid bottle, bottle to contain sample of milk to be be tested, can of tablets to preserve the milk, scales for weighing the milk when drawn from the cow, daily record sheet for number of pounds of milk produced by each cow at each milking.

Problem 234. Write a short essay on how milk should be handled on the farm.

Problem 235. In the evening, secure a quantity of milk and keep it over night in a medium, but not cold, temperature. Early in the morning mix it thoroughly, and pour equal quantities into each of four pint bottles or glass fruit jars. (These jars should be thoroughly washed and scalded before the milk is poured into them.) Cover the jars or bottles with paper to prevent the entrance of dust. Then place one bottle in a dish or pail of ice-water, one in water at 55° or 60°, one at 70° to 75°, and the other at 90° to 100° Fahrenheit. It will be well to shake the bottles frequently when first put into the water, until the milk becomes the same temperature as the water. Keep the water in the dishes at the above temperatures throughout the day, and notice when the milk in each jar first tastes sour, and also when it curdles. In which does it sour first? Which last? Why? What does this teach about the handling of milk?

Problem 236. The Babcock test, to determine the richness of milk, or the percentage of fat it contains:

Utensils. — A hand-power centrifugal Babcock tester, at least two milk test bottles, one pipette to measure the milk, one acid measure, about one pint of sulfuric acid with specific gravity between 1.82 and 1.83, a few ounces of milk, and some hot water. All the necessary apparatus and acid can be purchased for about five dollars from any dairy supply company. They can be ordered through a hardware dealer. Sulfuric acid is sold also at drug stores. Perhaps the equipment can be borrowed from a dairy farmer in the locality. If there is a creamery or skimming station near by, the class may go there to perform the test.

Sampling the milk. — The milk to be tested should be thoroughly mixed just before the sample is taken, to make sure that the fat or cream is evenly distributed. This can best be done by gently pouring back and forth between two vessels several times. The milk should be neither very cold nor hot.

Place the small end of the pipette at the center of the milk and suck the milk up above the 17.6 cc. mark on the tube. Quickly place the index finger over the upper end of the pipette and by releasing the pressure allow the milk to run out until its upper surface is even with the 17.6 cc. mark when the pipette is held straight up and down.

Place the point of the pipette a short distance into the neck of the test bottle, holding it against the glass and with both pipette and bottle at an angle. Remove the finger to allow the milk to flow into the bottle. Be sure to get every drop of the milk, taking care to drain the pipette and

to blow the last drop into the bottle. A little practice should make any one skilful with the pipette.

It is best always to make this test in duplicate; hence, two bottles are needed for each lot of milk.

Using the acid. — The acid is very strong and must be handled with great care. If any gets on the hands, face, or clothing, it should be washed off quickly and water should always be ready for this purpose. *Do not leave the acid where young children can get it.*

After all the samples of milk to be tested have been measured, the acid should be added. Fill the acid measure to the 17.5 cc. mark with acid that is neither very cold nor hot. Pour this into the bottle with the milk, holding the bottle in a slanting position. The acid will then carry down any milk left in the neck and follow the glass surface to the bottom of the bottle and form a layer under the milk.

Hold the bottle by the neck and give it a circular motion for a few minutes, mixing the milk and acid until no milk or clear acid is visible. By this time the contents will be dark colored and hot. This change is due to the acid dissolving all the solid constituents of the milk except the fat, which it does not affect.

Whirling the bottles. — The bottles are whirled to separate the fat so that it can be measured. It is lighter than the remainder of the milk and will be forced to the surface. The bottles should be hot when whirled. If necessary they may be heated by standing in hot water before being put into the machine. A steam machine is easily kept hot when in use. Other kinds should have a small amount of boiling hot water placed in them.

Place the bottles in the machine so that each one will have another directly opposite, to keep the machine in balance. Whirl the bottles five minutes at the proper speed for the machine in use, directions for which come with the machine. Then stop it and, with the pipette or other convenient means, add hot water to each bottle until the contents come up to the bottom of the neck. Then whirl two minutes. Add hot water enough to bring the top of the fat nearly to the top of the graduations on the neck of the bottles. Whirl one minute. The fat should then form a clear column in the neck of the bottle.

Reading the percentage. — Keep the fat warm so that it will be in a fluid condition. Hold the bottle by the upper end of the neck, allowing it to hang in a perpendicular, or upright position, on the level with the eye. Read the mark or graduations at the extreme top and bottom of the fat column. The difference between these is the percentage of fat in the milk. Most test bottles are made to read as high as 10 per cent. Each percentage has its number marked on the glass and there are five small spaces,

each representing .2 per cent, between these principal marks. Thus, if the top of the fat column is even with the third short mark above the 7 mark, the top reading would be 7.6; and if the bottom is halfway between the first and second short marks above the 3 mark, the bottom reading would be 3.3; the difference is 4.3, which is the percentage of fat, or the number of pounds of fat in 100 pounds of the milk tested.

Notes. — Specific gravity means the weight of the acid compared with the weight of an equal volume, or amount, of water. The sulfuric acid should be about 1.82 times as heavy as water.

1 cc. means 1 cubic centimeter, or about 20 drops.

If the fat column is clouded with white specks, probably the acid was not strong enough, or not enough was used, or the temperature was not high enough.

If the fat column is clouded with dark specks, probably the acid was too strong, or too much was used, or the heat was too great

Always keep the acid bottle closed when not in use, or the acid will lose strength. Remember that it is a poison and that it will burn wood or clothes that it touches.

CHAPTER XLI

THE IMPROVEMENT OF ANIMALS

From our study of farm animals we have learned that they have undergone great changes since the time when man first captured them from the wild. Some have been transformed so much that they now bear little resemblance to their ancient ancestors. The changes, or improvements, have been of such a nature as to make them more useful to man.

The breeding of animals. — All animals grow old and die, or are slaughtered for food. Other animals are born and take their places. Not only is a new animal born to take the place of one that dies, but every pair of animals is able to produce more than two others. As a result, the total number of animals in the world increases.

But it is not enough that new animals and more of them shall appear. These new animals must be desirable and useful. They must possess qualities or characteristics or habits that will make them valuable or serviceable. In order to be sure that his new animals will have the qualities or characteristics that he wants them to have, the stockman chooses the parents. This choice of parents so as to secure offspring with particular characteristics is called "breeding."

Objects of breeding. — The farmer who breeds cattle may have either one of two objects in mind. He may wish to maintain, or keep, the type of his animals just as they are, without any special change; or he may desire to produce a new type or breed that will be wholly different from the parents. A stockman who has small red cows may desire to produce others like them; or he may wish from the animals to produce large red cows. In the former case,

he desires to maintain, or continue, his type; in the latter, he desires to produce a new type. Some stockmen are endeavoring just now to produce a new type or race of animals, called cattaloes, by choosing one parent from common farm beef animals and the other from the buffalo tribe.

FIG. 171. — Southdown ewe. Developed as a medium wool-mutton type.

What to breed for. — A carpenter does not begin to build a house until he or the architect has drawn plans and knows just what the completed house should look like in all of its parts. In the same way, the stockman should have in mind just what form or type of animal he wants to secure before he begins to breed. The carpenter has in mind an ideal house he wishes to build; the stockman

must have in mind an ideal animal he wishes to develop. This is the first step in the improvement of animals, and it is the most important because everything else in breeding will be shaped by the object, or ideal, it is desired to secure.

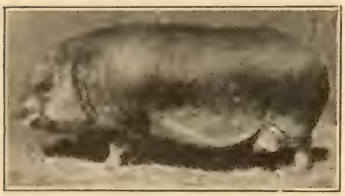

Fig. 172. — Duroc-Jersey, an excellent breed that has been developed in America from common hogs.

The choice of parents. — After the carpenter has planned his house and has his ideal in mind, he chooses such materials as will give him the appearance in the house that he wants. He does not use anything and everything that comes to hand.

Such a choice of materials, or rather of parents, is equally important for the stock-breeder. If he is to secure new animals that will be like the ideal he has in mind, he must choose parents that are most likely to produce that ideal. In other words, he should look over his herd and choose for parents the animals that already are nearest to his ideal.

If a farmer's herd is comprised of small red cattle with long horns, and he desires to develop a new herd of large red cattle with short horns, he will choose for parents the animals that combine largest size with the shortest horns. He may not be able to take the largest of his cows because she may have exceptionally long horns. And he may not be able to take the one with the shortest horns, for she may be a very small animal. He will have to choose the ones that, on the average, seem to have the best combination of size with shorter horns. He will breed from such animals unless they have other characteristics that are undesirable.

The offspring. — The stockman cannot expect that the first offspring will measure up to his ideal. But it will be a step toward it. Perhaps the first offspring will be larger than the parents, but have the same length of horns; or perhaps it will be of the same size as the parents, but have shorter horns; or perhaps it will com-

bine the two and be slightly larger, with horns that are a trifle shorter. Well and good; some progress has been made toward the ideal.

The second step is to use this offspring for one of the parents of a new generation, and to choose to mate with it an animal of the other

FIG. 173. — Guernsey cow. This animal has descended from parents that were bred, or developed, for dairy type.

sex that most nearly represents the ideal. The offspring of this pair is likely to show still further progress toward the ideal.

The stockman who sets out to improve his animals or to create a new type or breed must have patience. His results will come slowly, a little at a time. But so long as he holds to his ideal, and always chooses the parents that most closely resemble that ideal, he will make progress, unless he is trying to accomplish something

that is impossible. Patience and perseverance are essential qualities in the successful stock-breeder.

Pedigree. — Farmers who breed live-stock speak frequently about the *pedigrees* of their animals. They do not care to use an animal for breeding unless it has a good pedigree. Let us see what they mean.

Animals, like human beings, have parents, and grandparents, and great-grandparents, and others in succession reaching away back

FIG. 174. — Saddle horse. Developed by combining trotting horse and coach horse characteristics, so as to secure seed, weight, and appearance.

to the beginning. Most of the characteristics of an animal now living are what it has inherited from its ancestors. If the ancestors of a dairy cow have all been of medium size, black and white, and have been heavy producers of milk, we can expect with much certainty that the present cow will show the same characteristics. If the ancestors have not been chosen with any care, and some have been large, others small, there has been no attention paid to

the color, and there have been both good and poor milk-producers in the list, we cannot tell what to expect from the present animal. We do not know what to expect of her offspring. In the former case, we say the cow has a good pedigree, in the latter a poor pedigree.

We may define a pedigree, then, as the connected record or list of all the ancestors of an animal. If the achievements or qualities

FIG. 175. — Morgan. A light driving horse that the United States government is now breeding.

of the ancestors have been almost uniformly good, the animal is said to have a good pedigree; if they have been mixed or poor, the pedigree is poor.

The longer any line, or family, of animals is bred to a certain standard or ideal, the more uniform will the offspring represent that ideal. For this reason, the farmer who wishes to improve his stock desires to use animals for parents that have had good pedigrees so that their good qualities are "fixed," or established. He then

has confidence that he will secure certain results. And he can do his work intelligently, as he knows what to expect from his animals.

Improving the farm live-stock. — How is the farmer to improve his live-stock if he has only poor or medium animals whose ancestry is largely unknown or whose pedigree is poor? It is not

FIG. 176. — Mules are the product of animal breeding. They are hybrids, or crosses, between the horse and the ass.

necessary for him to sell all that he has and buy good animals. He can begin with what is on hand.

Improvement in the farm herd or flocks will be brought about by breeding from the best animals only and gradually selling all the others. The father of the herd is such an important part, that the farmer will improve his animals much faster if he buys a sire that has a good pedigree. The second generation should then be better than the first, the third better than the second, and so on. Many excellent herds have been built up in this way.

Problem 237. Are most of the farm animals in your neighborhood common stock or "grades," or are they pure-bred? What do we mean by pure-bred stock?

Problem 238. What kinds of cows, grades or pure-breds, have the farmers who are producing the most milk? If any of them have pure-bred stock, do they sell the calves? Do they receive more for the calves than the man who sells grade stock?

Problem 239. Are pure-bred stock, more, or less, expensive to keep than common grade stock?

Problem 240. If there are cattle on your father's farm or a neighboring farm, find out whether the poorest cows in the herd eat as much as the best cows. Would it pay to dispose of the poor cows and improve the herd so that all will be nearly as good as the best cows?

Problem 241. Borrow a written pedigree of one of the best animals in the neighborhood. Ask the owner to explain it to you. Find out particularly why it is a good pedigree. Then bring it to school and explain it to the class.

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